

sPHENIX Cost and Schedule Review

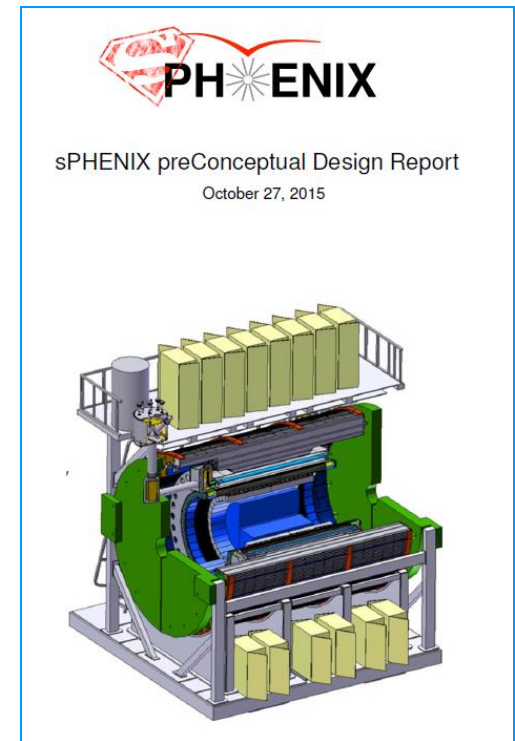
Project Management Break Out

Nov 9-10, 2015

BNL

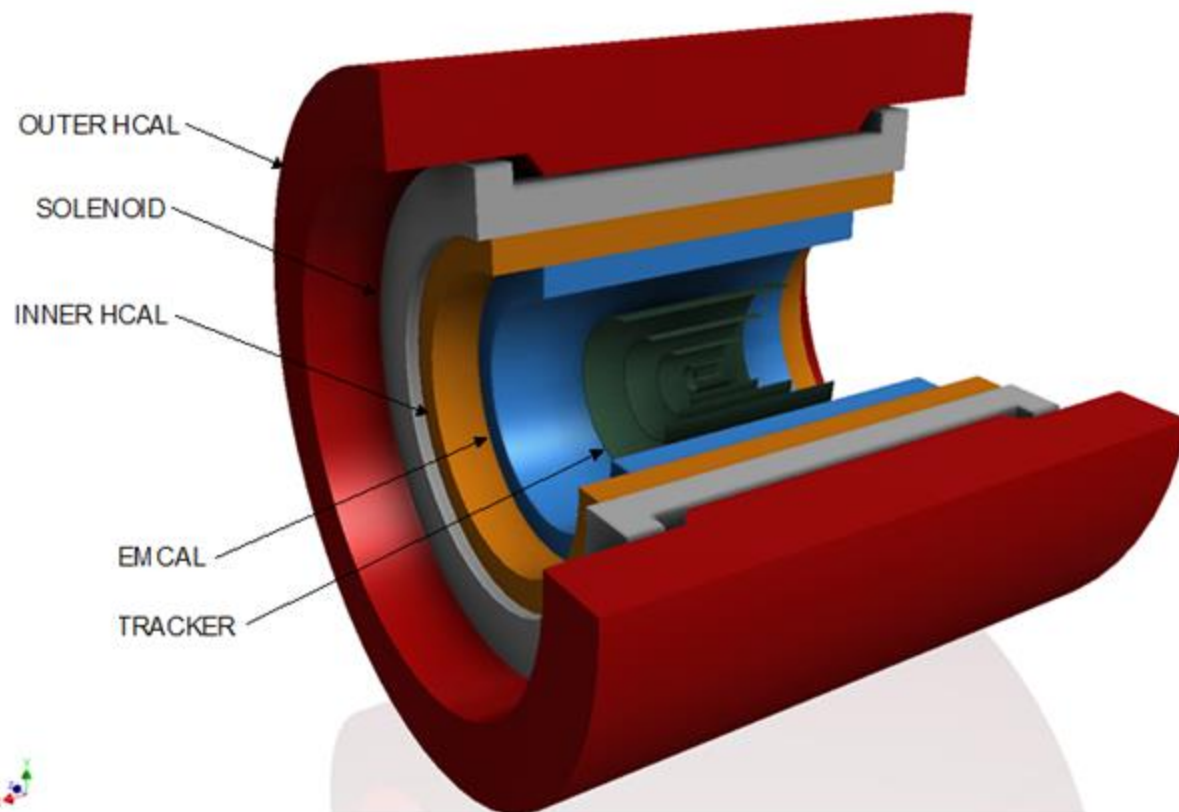
Documentation Made Available to the Committee

- Preliminary Conceptual Design Report
- WBS and WBS Dictionary
- sPHENIX Science Proposal to DOE plus DOE Review report
- Basis of Estimate Documents
- Preliminary Risk Analysis and Mitigation Document
- Recommendation Resolution Database
- Preliminary Safety and Hazard Analysis
- Preliminary Quality Assurance Plan



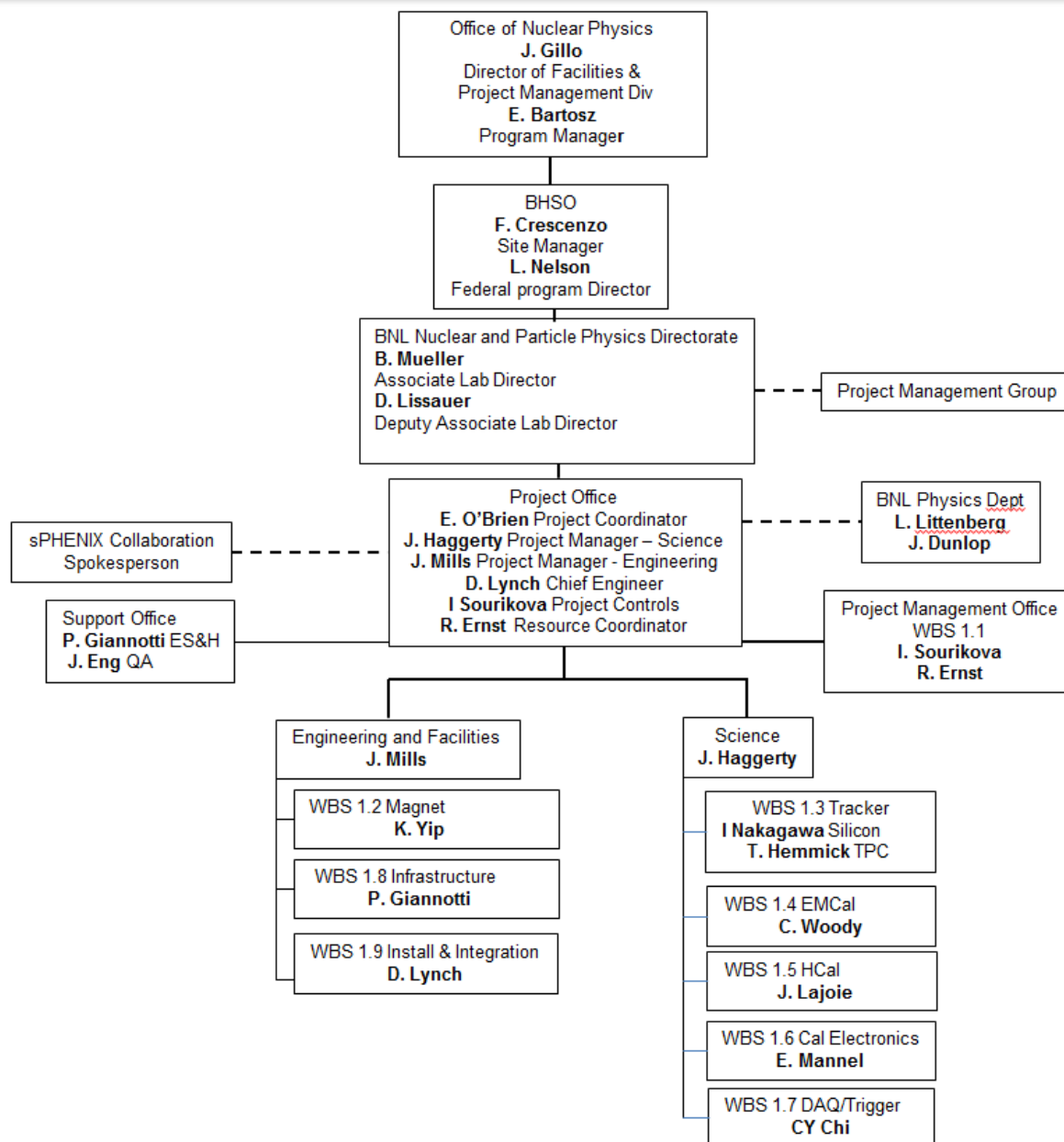
sPHENIX Project Scope

- 1.1 Project Management
- 1.2 SC-Magnet
- 1.3 Tracker
- 1.4 EMCal
- 1.5 HCal
- 1.6 Calorimeter Electronics
- 1.7 DAQ/Trigger
- 1.8 Infrastructure
- 1.9 Installation/Integration



*** Tracker to be funded from outside sources, Japanese funding agencies, NSF and other international sources.**

Project Organization



Basis for the Project Plan

- Defined the complete Project including all components of the Total Project Cost, and key off-Project tasks like Decommissioning and the Cold Acceptance Tests of the SC-Magnet.
- Defined a WBS structure
- Assigned cognizant engineers and scientists to define all project tasks, durations, fixed(M&S) costs and labor assignments by labor category
 - 40-45 people worked on this
 - > 1600 tasks defined
- Everything entered into MS-Project (no P6 expertise on the project yet)
- Estimated all material costs through engineering estimates, discussions with vendors, previous experience.
 - ~ 80 items with costs \geq \$50k. Wrote a Basis of Estimate for.
- Assigned BNL labor rates to appropriate job categories
- Linked all tasks to create resource loaded schedule plus budget
- We also had the engineers and scientists fill out contingency estimates for each task based on material and labor risks. We have the ingredients for a bottoms-up contingency estimate, but it's not yet implemented.

1 sPHENIX Design, Production, Commissioning

1.1 Project Management

1.2 Magnet

1.3 Tracker

1.4 EMCal

1.5 HCal

1.6 Calorimeter Electronics

1.7 DAQ/Trigger

1.8 Infrastructure

1.9 Installation/Integration

2 sPHENIX Preconceptual Activities

2.1 Decommissioning

2.2 Magnet Acceptance Testing

2.3 Tracker Generic R&D and Preconceptual Design

2.4 EMCal Generic R&D and Preconceptual Design

2.5 HCal Generic R&D and Preconceptual Design

2.6 Calorimeter Electronics R&D and Preconceptual Design

2.7 DAQ/Trigger generic R&D and Preconceptual Design

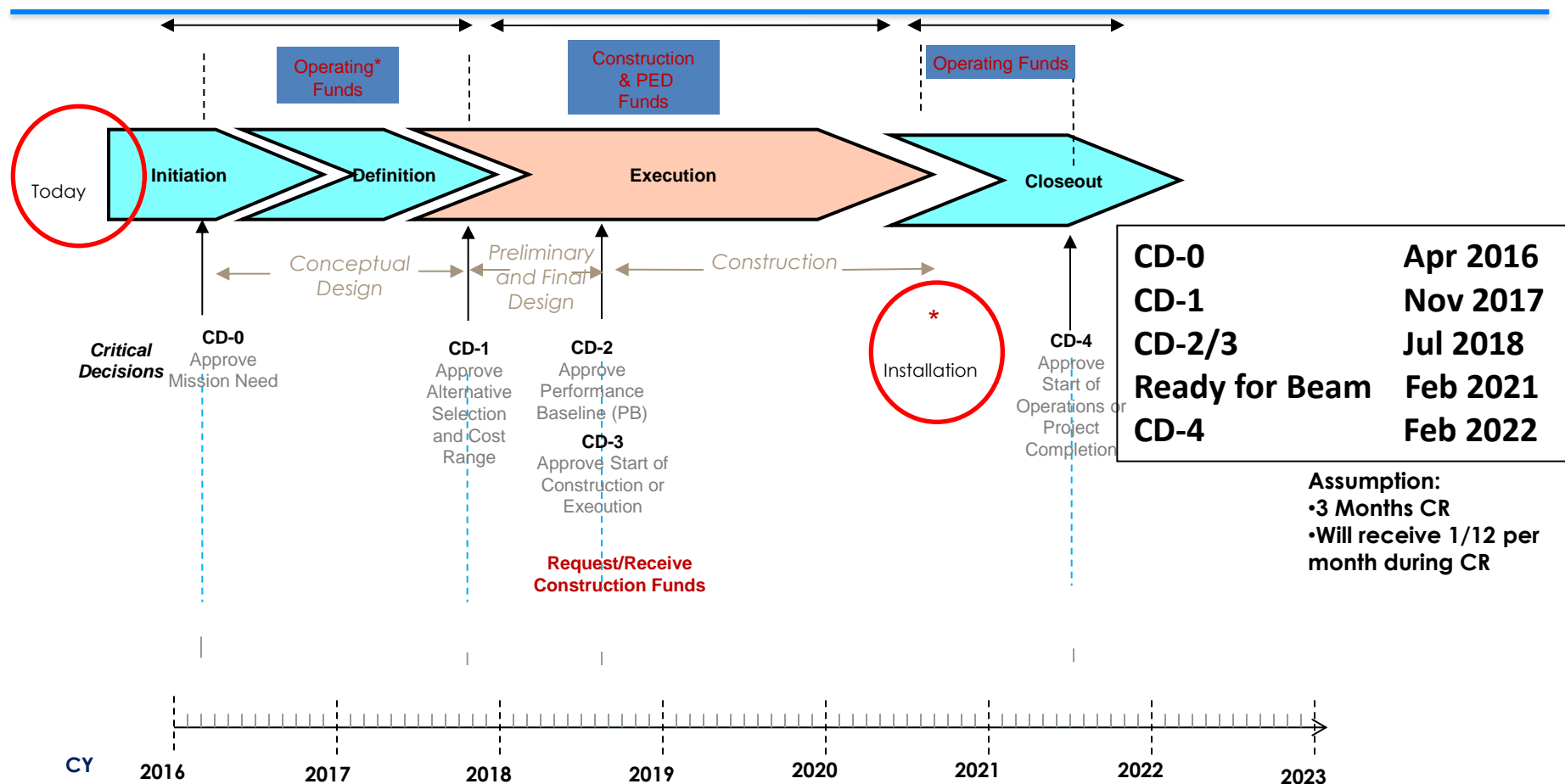
2.8 Infrastructure Preconceptual

2.9 Installation and Integration Preconceptual

The WBS structure was designed for:

- Natural separation of on-project and off-project costs and resources
- Allows one to balance resources and link tasks between on-project and off-project WBS elements
- No major changes to WBS structure once we get CD-1

Critical Decision Scenario



•Operating Funds are used for conceptual design between CD-0 and CD-1. Operating funds may also be used prior to CD-4 for R&D, NEPA, D&D, ES&H, transition, startup, and training costs. Non-federal funds from other sources that are considered capital funds and are included in the "Total line item cost" as OPC.

•Good Practice—For the first year that TEC is requested, ensure that OPC is also requested for that year. The OPC will allow the project to continue in a long CR until TEC is available and new starts are allowed.

•MIE funds are more flexible than Line Items. Moving OPC to TEC or vice versa is much easier than for Line-Item reprogramming since MIE funds are "batched."

•New Start is defined as the first use/appropriation of any TEC funds (including TEC PED) for both line items and MIEs project.

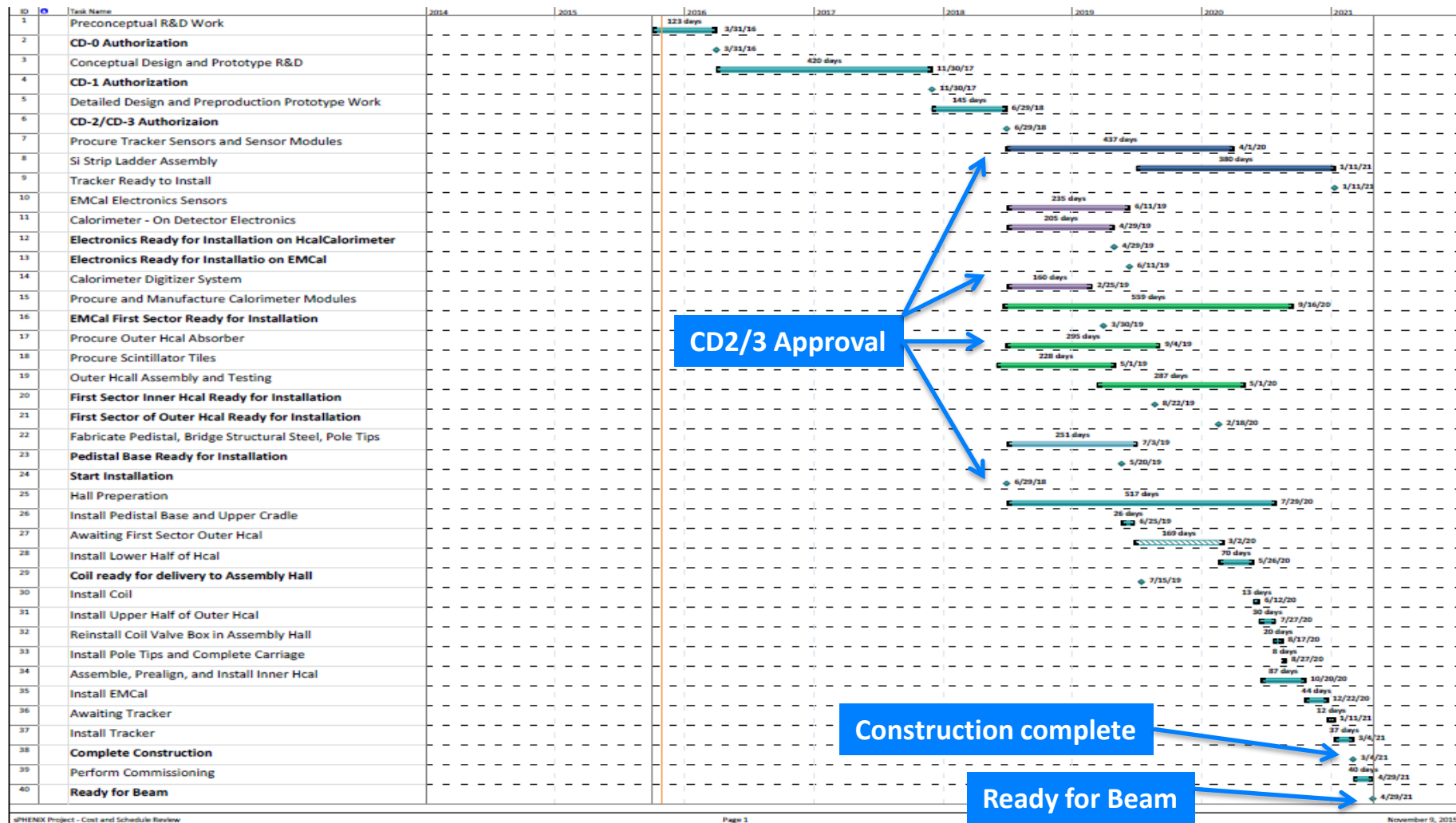
sPHENIX Schedule

Initial schedule shows Installation complete **Mar 1 2021**. Commissioning complete **Apr 29, 2021**.

Based on authorization for CD-1 Nov 2017, CD-2/3 Jul 2018.

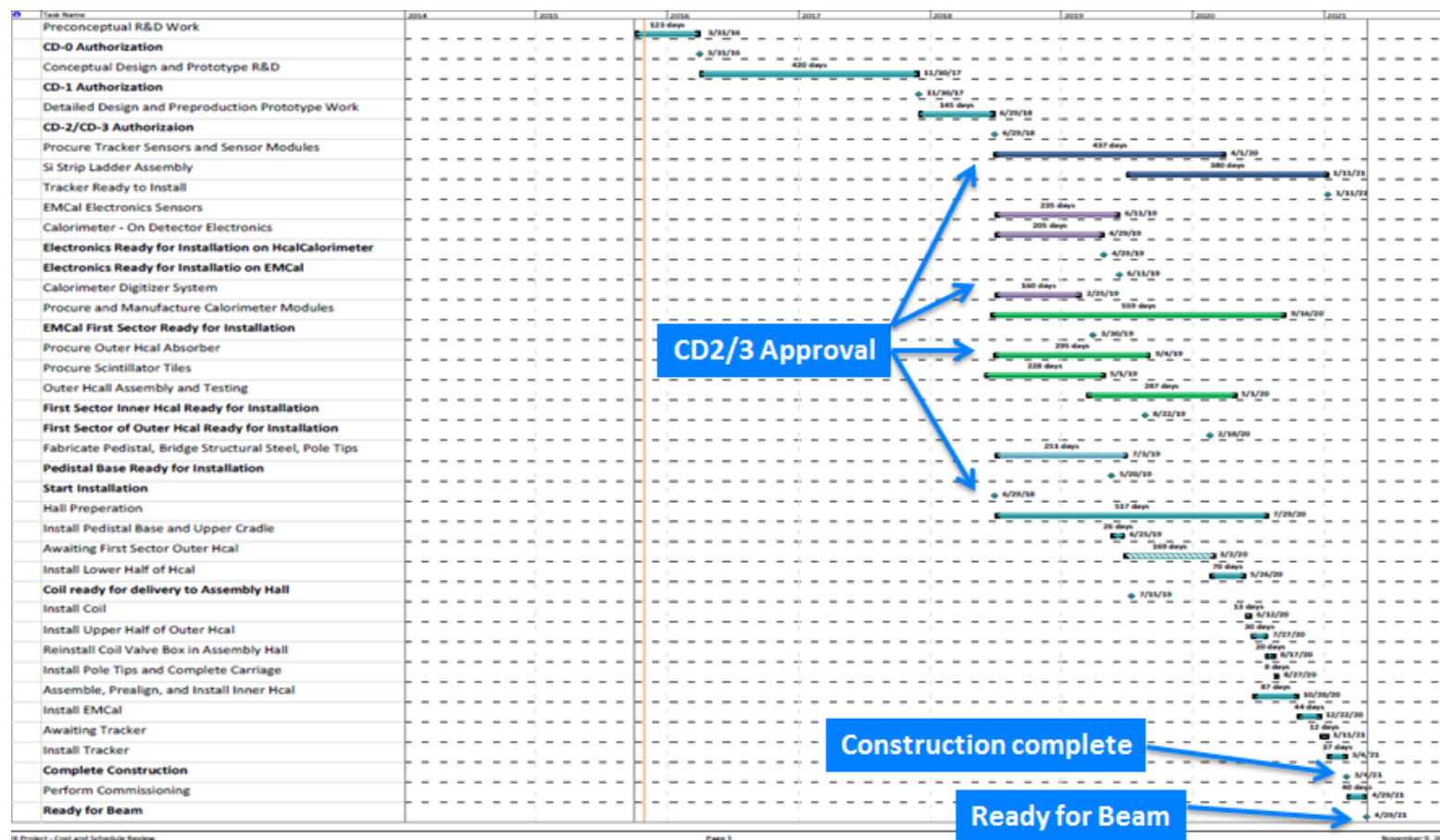
Two approaches to address the tight schedule:

1) CD-3a in Nov 2017 for long lead time items. 2) One year stretch in the schedule



sPHENIX Schedule

- A CD-3a for HCal steel procurement at time of CD-1 and permission to begin SiStrip production in Japan at CD-1 brings the Ready for Beam date back to Jan 2021.
 - SiStrip production start is on critical path with HCal steel purchase lagging by 3 wks
- For a 1 year schedule stretch, and no CD-3a, has the detector Ready for Beam date is May 1, 2021 with a 7 month float to RHIC beam in Jan 2022.



Material Cost by FY & WBS Category

All in FY16\$

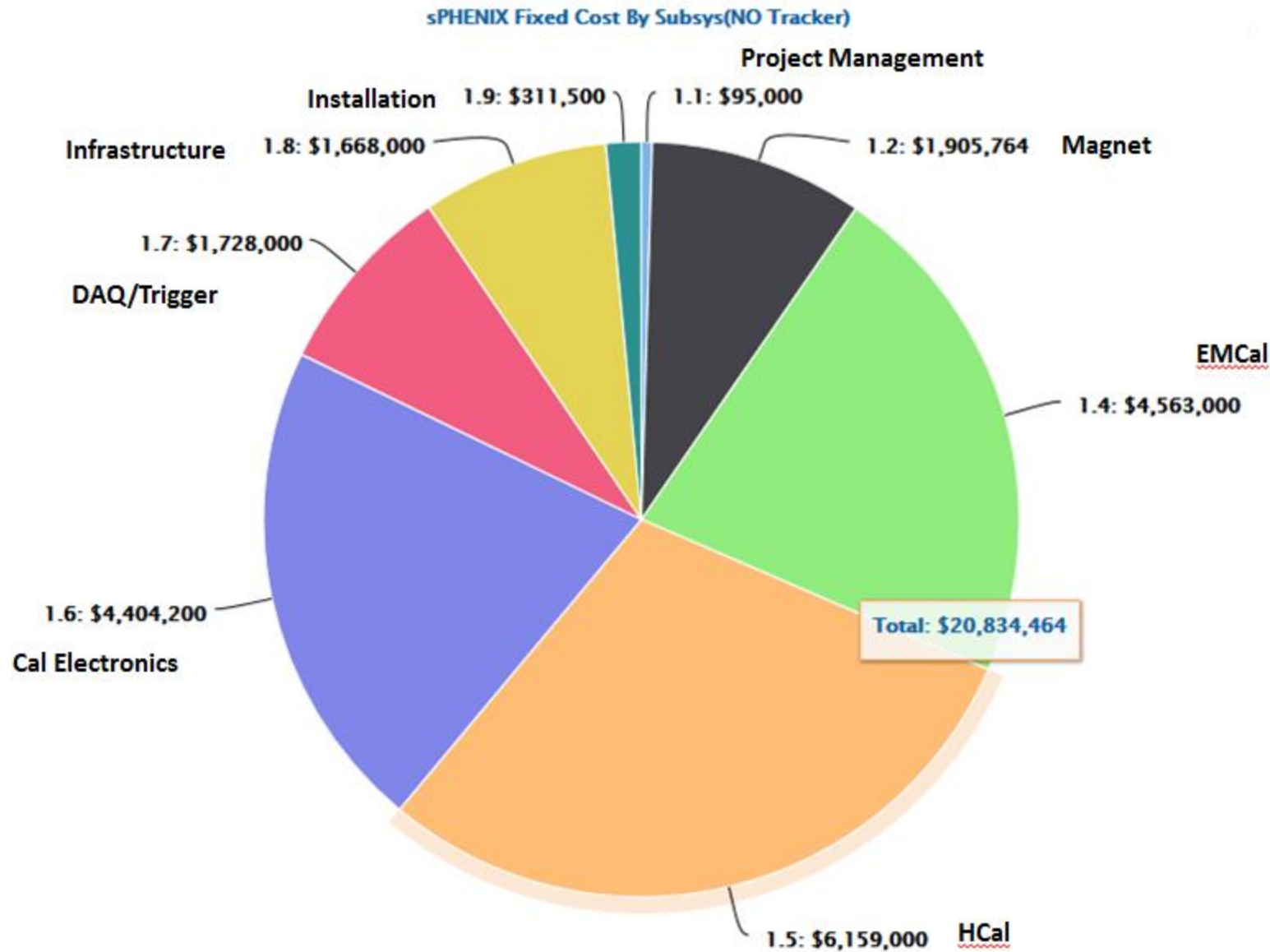
Sum of Fixed Cost		Column Labels						
Row Labels	Descriptions	2016	2017	2018	2019	2020	2021	Grand Total
1.1	Project Mgt	10,000	20,000	20,000	20,000	20,000	5,000	95,000
1.2.	Magnet			1,877,764	28,000			1,905,764
1.4.	EMCal	35,000	263,000	565,000	3,700,000			4,563,000
1.5.	HCAL			5,999,000	160,000			6,159,000
1.6.	Cal Elec	105,000	107,000	4,162,200	30,000			4,404,200
1.7.	DAQ & Trigger	16,000	71,000	1,116,000	525,000			1,728,000
1.8.	Infrastructure			1,075,000	593,000			1,668,000
1.9.	Installation			263,000	7,500	29,000	12,000	311,500
Grand Total		166,000	461,000	15,077,964	5,063,500	49,000	17,000	20,834,464

\$20.8M, ~6% above Nov 2014 estimate

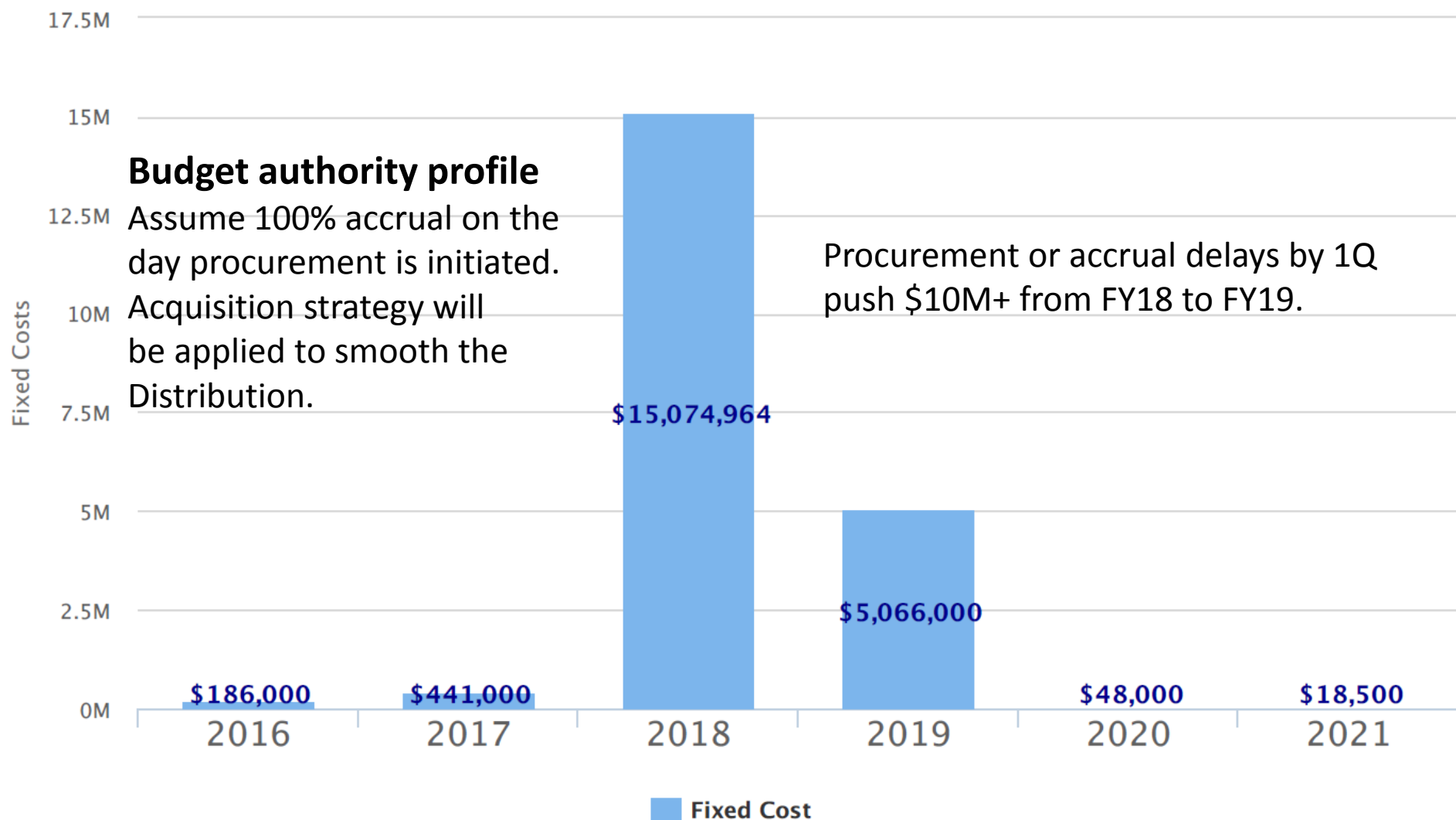
Budget savings are being investigated including :

- Min Bias Trigger Det in WBS 1.7 contributed by international institution (\$0.5M)
- R&D being performed now may mitigate the need to charge this work to the TPC
- NSF contributions (**for instance EMCal electronics, \$4M**)
- Retirement of risk and assoc. contingency reduction as R&D advances
- General scrubbing

Material Costs by Subsystem w/o Tracker



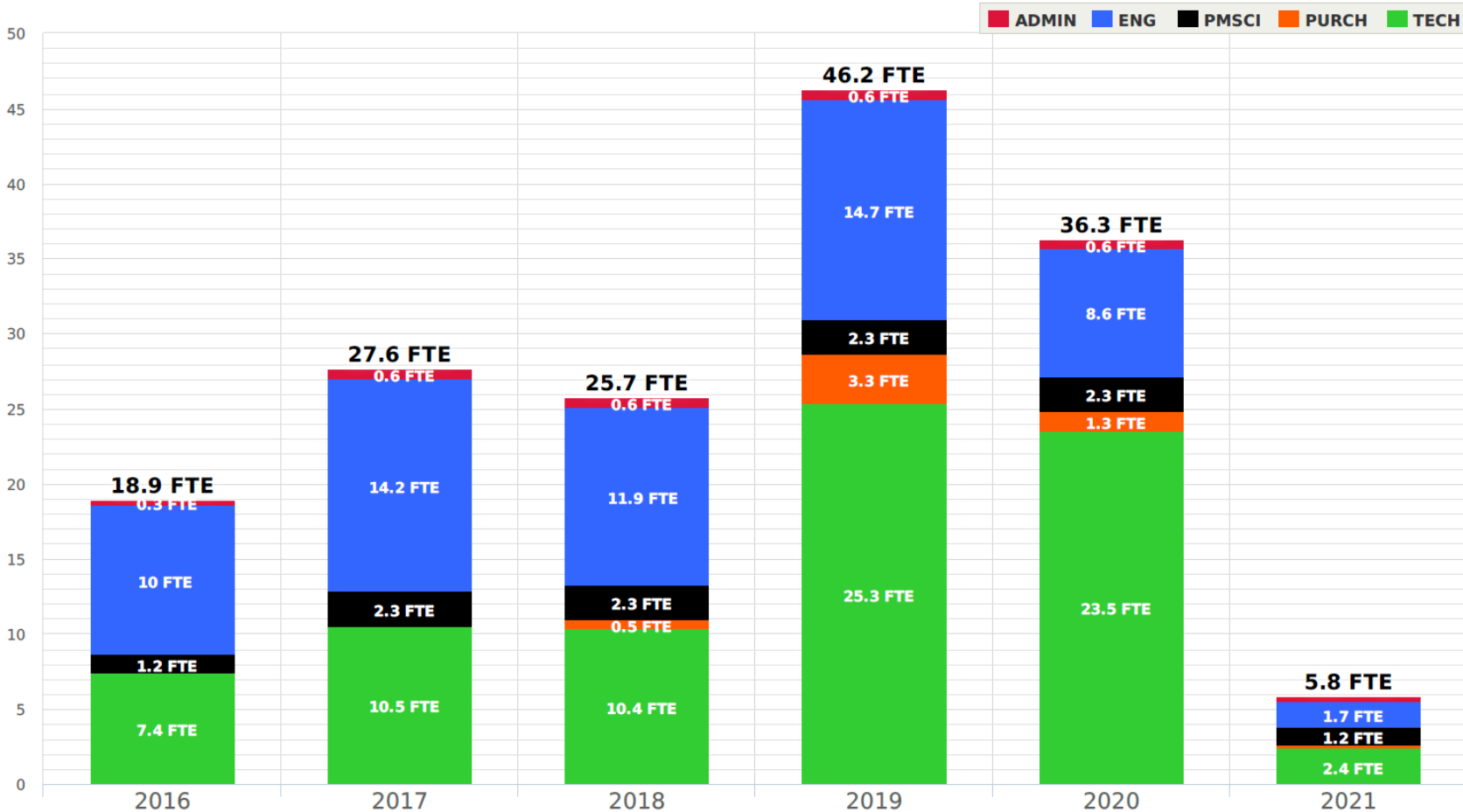
Material Cost Profile -Direct



Labor Profile for DOE Project

University contributions of scientists and students not shown

SPHENIX LABOR BY CATEGORY

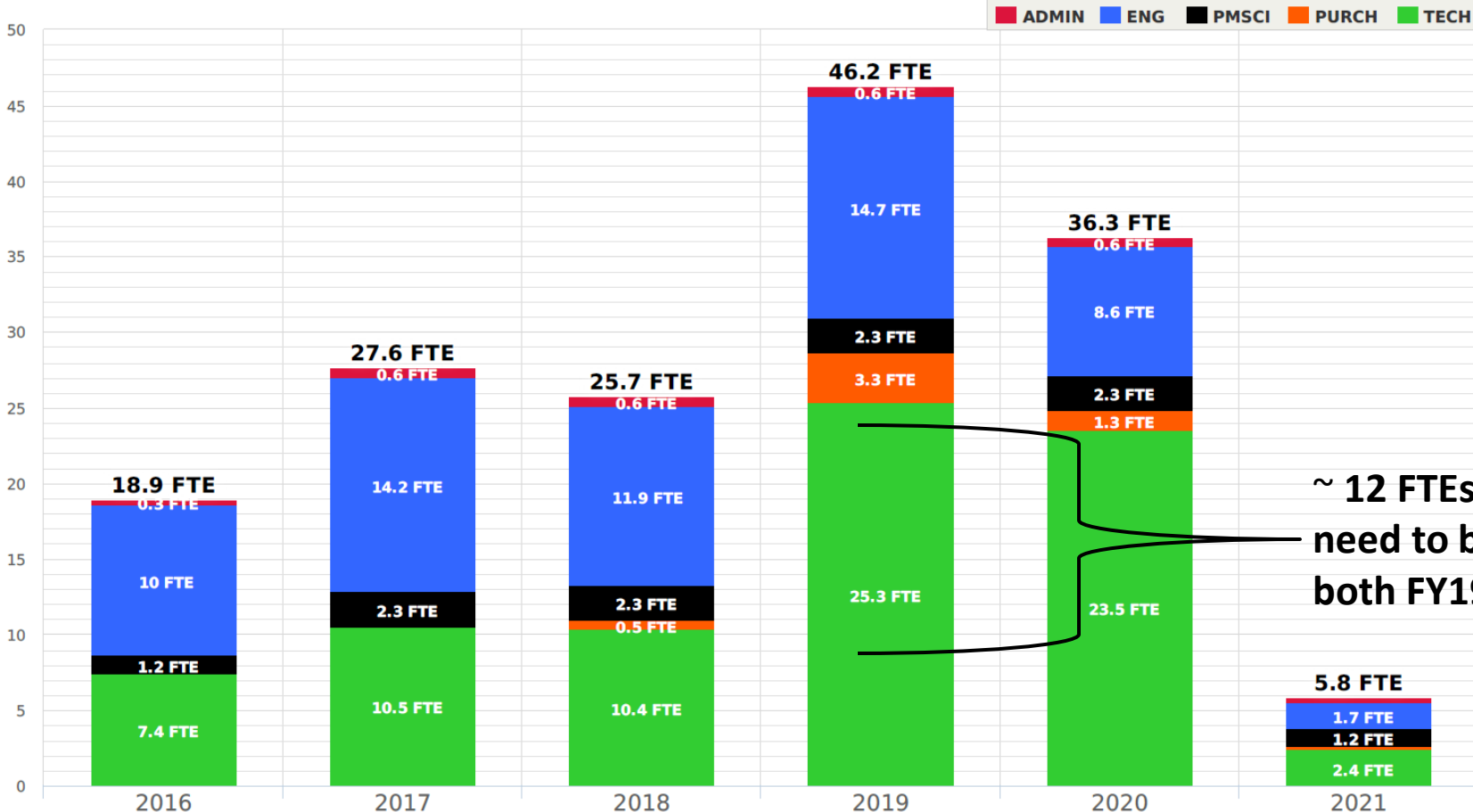


Almost all engineers and on-project scientists have been identified along with ~10 FTEs of techs. A challenge is the technician “bump” in FY19-20.

Labor Profile for DOE Project

University contributions of scientists and students not shown

SPHENIX LABOR BY CATEGORY



Two approaches to address technician bump in FY19/FY20:

- 1 year schedule stretch smooths the bump and makes it manageable (+\$500k)
- Cover work by a combination of univ labor, job shoppers, vis sci, students (- \$2000k)

The second approach creates a “re-direct” challenge

Labor Cost by FY & WBS Category

All in FY16\$

Costed at BNL labor rates

Row Labels	WBS Description	FY 16	FY 17	FY 18	FY 19	FY 20	FY 21	Grand Total
1.1	Project Management	\$545,173	\$1,059,252	\$1,053,624	\$1,068,883	\$1,073,176	\$511,967	\$5,312,075
1.2	Magnet	\$760,847	\$663,760	\$838,987	\$1,155,310	\$548,814	\$6,847	\$3,974,566
1.4	EMCaL	\$252,504	\$669,520	\$707,488	\$1,901,348	\$1,811,637	\$19,859	\$5,362,356
1.5	HCAL	\$740,666	\$976,017	\$746,224	\$1,373,509	\$1,547,746		\$5,384,163
1.6	Cal Elec	\$249,224	\$435,659	\$284,193	\$494,177	\$40,656		\$1,503,909
1.7	DAQ & Trigger	\$101,124	\$177,306	\$197,661	\$342,092	\$36,528		\$854,710
1.8	Infrastructure	\$399,598	\$547,268	\$200,354	\$715,743	\$64,325		\$1,927,289
1.9	Installation	\$119,246	\$103,883	\$262,111	\$449,811	\$599,895	\$437,945	\$1,972,890
Grand Total		\$3,168,383	\$4,632,666	\$4,290,642	\$7,500,873	\$5,722,778	\$976,618	\$26,291,958

Budget changes are being investigated including

Reductions:

- Substituting fraction of BNL Techs in FY19, FY20 for Visiting scientists, contract labor and students, or stretching the schedule allowing the techs to spread into FY21.
- R&D being performed now under LDRDs and Program Development Funds may mitigate the need to charge some work in FY16-FY18 to the TPC
- Retirement of risk and assoc. contingency reduction as R&D advances
- General scrubbing

Increases:

- A 1 year schedule stretch out adds ~\$400k in escalated labor costs

Assigned Labor Rates

Labor rates assigned with FY16 BNL Labor bands and sorted by Department

Exerpt from Microsoft Project Resource Table

Resource Name	Type	Group	Std. Rate	Accrue At	Base Calendar	Code
ADMIN1 PO	Work	Administrative	\$83.15/hr	Prorated	SPHENIX_Holidays_Only	Physics
PROF3 PO E	Work	Engineering	\$89.84/hr	Prorated	SPHENIX_Holidays_Only	Physics
PROF3 PO M	Work	Engineering	\$89.84/hr	Prorated	SPHENIX_Holidays_Only	Physics
PROF4 PO E	Work	Engineering	\$104.30/hr	Prorated	SPHENIX_Holidays_Only	Physics
PROF4 PO M	Work	Engineering	\$104.30/hr	Prorated	SPHENIX_Holidays_Only	Physics
SCI3 PO	Work	Scientific	\$121.50/hr	Prorated	SPHENIX_Holidays_Only	Physics
TECH3 PO E	Work	Technical	\$81.10/hr	Prorated	SPHENIX_Holidays_Only	Physics
TECH3 PO M	Work	Technical	\$81.10/hr	Prorated	SPHENIX_Holidays_Only	Physics
TECH3 PO D	Work	Technical	\$81.10/hr	Prorated	SPHENIX_Holidays_Only	Physics
ADMIN1 AD	Work	Administrative	\$83.15/hr	Prorated	SPHENIX_Holidays_Only	CA-D
PROF3 AD	Work	Engineering	\$89.84/hr	Prorated	SPHENIX_Holidays_Only	CA-D
PROF4 AD	Work	Engineering	\$104.30/hr	Prorated	SPHENIX_Holidays_Only	CA-D
SCI3 AD	Work	Scientific	\$121.50/hr	Prorated	SPHENIX_Holidays_Only	CA-D
TECH3 AD	Work	Technical	\$81.10/hr	Prorated	SPHENIX_Holidays_Only	CA-D

Used Standard band rates (nearest) the average rate of the Physics Staff population currently charging Experimental Operations.

Use a standard productive hours of 1760

The project files also include the standard BNL Holiday schedule.

Standard Labor Rates for FY16 as of Sep 1, 2015				
Band	Fringe Rate	(Union Esc)		
		2080 hrs	2088 Hrs	FY 16 Annual Cost Salary and Fringe
ADMIN1	39.0%	1,763.12	42.25	\$ 74,491.82
ADMIN2	39.0%	1,717.97	53.30	91,567.68
ADMIN3	39.0%	1,729.61	63.15	109,224.75
ADMIN4	39.0%	1,729.81	76.20	131,811.79
ADMIN5	39.0%	1,768.78	92.70	163,966.04
ADMIN6	39.0%	1,768.27	122.70	216,967.22
ADMIN7	39.0%	1,780.12	159.20	283,395.30
PROF1	39.0%	1,816.72	50.00	90,836.20
PROF2	39.0%	1,778.95	72.10	128,262.02
PROF3	39.0%	1,774.55	89.85	159,443.72
PROF4	39.0%	1,772.83	104.30	184,906.00
PROF5	39.0%	1,756.46	121.70	213,761.68
PROF6	39.0%	1,785.10	144.00	257,053.92
SCI1	39.0%	1,876.30	86.70	162,675.56
SCI2	39.0%	1,802.63	106.30	191,620.06
SCI3	39.0%	1,795.36	121.50	218,136.81
SCI4	39.0%	1,799.65	144.35	259,779.51
SCI5	39.0%	1,778.10	179.05	318,369.17
SEASONAL	39.0%	2,058.66	22.80	46,937.36
TECH1	39.0%	1,815.05	54.20	98,375.48
TECH2	39.0%	1,735.54	70.35	122,095.36
TECH3	39.0%	1,734.37	81.10	140,657.06
TECH4	39.0%	1,746.64	92.55	161,651.09

Budget Scenarios

Standard Scenario in the Project files:

- CD-1 start Nov 2017, CD2-3 start Jul 2018
- Need CD-3a of long lead time items to complete by Jan 2021
- Little float on the critical path
- Labor bump in Techs in FY19, FY20

Standard scenario with one year stretch

- Same CD1 and CD-2/3 starts
- W/O CD-3a, sPHENIX ready for beam May 2021 w/ 7 month float to Jan 2022 RHIC run
- Smooths tech bump
- Modest escalation costs

Standard Scenario with budget reductions

- Same CD1 and CD-2/3 start
- Need CD-3a of long lead time items
- Take credit for successful planned NSF MRI(EMCal electronics for instance)
- Fix FY19,FY20 tech bump (12 FTEs* 2 years) w/ Univ labor, Vis Sci, job shoppers & stdnts.
- Reduces savings from project labor burden. **Impacts potential redirects**

Standard Scenario in Project Plan

Summary of sPHENIX Cost Estimate at WBS Level 2

WBS	WBS Description	k\$'s		Total
		Labor	Material	
1.1	Project Management	5312	95	5407
1.2	Magnet	3975	1906	5880
1.4	EMCaL	5362	4563	9925
1.5	HCaL	5384	6159	11543
1.6	Calorimeter Electronics	1504	4404	5908
1.7	DAQ & Trigger	855	1728	2583
1.8	Infrastructure	1927	1668	3595
1.9	Installation/Integration	1973	312	2284
Subtotal sPHENIX TPC FIX FY 16 k\$		26292	20834	47126
Indirect Estimates		8992	1945	10937
Escalation Estimate		2643	1021	3664
Subtotal sPHENIX TPC FY fully Loaded AY k\$		37927	23800	61727
Contingency Estimate		5987	6955	12942
Total sPHENIX TPC * (k\$)		43914	30755	74669

Includes overhead, contingency and escalation

Labor - based upon BNL FY 16 published standard labor band rates (salary & fringe) as of September 1, 2015.

Composite indirect rates includes: organizational burdens, and all applicable Laboratory applied overhead and burdens at the extraordinary construction rate as of September 1, 2015.

Compounded Escalation: 3% on Labor and 2% on Material

Contingency 5% on OPC activities; 20% on TEC Labor and 30% on TEC Material

* based on pre CD-0 estimates

Standard Scenario w/ 1 Year Stretch

All BNL Labor - Different Contingency Approach - 1 Year Stretch

Summary of sPHENIX Cost Estimate at WBS Level 2

WBS	WBS Description	k\$'s		Total
		Labor	Material	
1.1	Project Management	5312	95	5407
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1.8	Infrastructure	1927	1668	3595
1.9	Installation/Integration	1973	312	2284
Subtotal sPHENIX TPC FIX FY 16 k\$		26292	20834	47126
Indirect Estimates		8992	1945	10937
Escalation Estimate		3003	1021	4024
Subtotal sPHENIX TPC FY fully Loaded AY k\$		38287	23800	62087
Contingency Estimate		6059	6955	13014
Total sPHENIX TPC * (k\$)		44346	30755	75101

Stretching the program Fixed FY 16 cost remain the same, impact to escalation and contingency.

Labor - based upon BNL FY 16 published standard labor band rates (salary & fringe) as of September 1, 2015.

Composite indirect rates includes: organizational burdens, and all applicable Laboratory applied overhead and burdens at the extraordinary construction rate as of September 1, 2015.

Compounded Escalation: 3% on Labor and 2% on Material

Contingency 5% on OPC activities; 20% on TEC Labor and 30% on TEC Material

* based on pre CD-0 estimates

Reduced Cost Scenario w/ No Stretch

All BNL Labor - Different Contingency Approach- Material and Labor Savings

Summary of sPHENIX Cost Estimate at WBS Level 2

WBS	WBS Description	k\$'s		Total
		Labor	Material	
1.1	Project Management	5312	95	5407
1.2	Magnet	3975	1906	5880
1.4	EMCaL	3208	4563	7771
1.5	HCaL	5384	6159	11543
1.6	Calorimeter Electronics	1504	404	1908
1.7	DAQ & Trigger	855	1728	2583
1.8	Infrastructure	1927	1668	3595
1.9	Installation/Integration	1973	312	2284
Subtotal sPHENIX TPC FIX FY 16 k\$		24138	16834	40972
Indirect Estimates		8255	1945	10200
Escalation Estimate		2327	859	3187
Subtotal sPHENIX TPC FY fully Loaded AY k\$		34720	19639	54359
Contingency Estimate		6549	6651	13200
Total sPHENIX TPC * (k\$)		41269	26290	67559

Contingency increased to 35% on materials and 25% on Labor

1.4 EmCaL assumes \$2154k in Fixed FY 16 labor savings and indirect and escalation savings

1.6 Calorimeter Electronics assumes \$4000k in Fixed FY 16 material savings and indirect and escalation savings

Labor - based upon BNL FY 16 published standard labor band rates (salary & fringe) as of September 1, 2015.

Composite indirect rates includes: organizational burdens, and all applicable Laboratory applied overhead and burdens at the extraordinary construction rate as of September 1, 2015.

Compounded Escalation: 3% on Labor and 2% on Material

Contingency 5% on OPC activities; 25% on TEC Labor and 35% on TEC Material

* based on pre CD-0 estimates

Budget Scenarios - continued

Standard Scenario		Standard Scenario w/ 1 yr stretch		Standard Scenario w/ Budget Reductions	
TEC Estimate	AY \$M	TEC Estimate	AY \$M	TEC Estimate	AY \$M
Labor	27.3	Labor	27.6	Labor	24.0
Material	23	Material	23.1	Material	19.0
Contingency (25%)	12.4	Contingency (25%)	12.4	Contingency (30%)	12.6
Subtotal TEC	62.7	Subtotal TEC	63.1	Subtotal TEC	55.6
OPC Estimate		OPC Estimate		OPC Estimate	
Labor	10.7	Labor	10.7	Labor	10.7
Material	0.7	Material	0.7	Material	0.7
Contingency (5%)	0.6	Contingency (5%)	0.6	Contingency (5%)	0.6
Subtotal OPC	12.0	Subtotal OPC	12.0	Subtotal OPC	12.0
Total Project Costs (TPC)	74.7	Total Project Costs (TPC)	75.1	Total Project Costs (TPC)	67.6

Budget Scenario Profiles

	2016	2017	2018	2019	2020	2021	2022	Grand Total
Standard Scenario								
Total AYk\$ with Burden & Contingency Estimate	4,667	7,299	29,552	20,839	10,459	1,854		74,669
Standard Scenario w/ 1 yr stretch								
Total AY \$ with Burden & Contingency Estimate	4,667	7,299	29,552	15,951	7,789	7,965	1,878	75,100
Standard Scenario w/ Budget Reductions								
Total AY \$ with Burden & Contingency Estimate	4,667	7,299	25,093	19,709	8,860	1,931		67,559

Standard Scenario

- Based on Project file. Ready for beam early 2021

Standard Scenario w/ 1 year stretch

- Based on Project file with additional 1 year stretch. Ready for beam in early 2022
- Total labor remains the same

Standard Scenario w/ Budget Reductions

- Based on Project file. Ready for beam early 2021
- ~12 FTE techs in FY19, FY20 assigned to job shoppers, Univ labor, Vis Sci, students
- Take credit for 1 successful NSF MRI

Budget Calculation in Detail

All BNL Labor - Different Contingency Approach

Summary Estimate

	2016	2017	2018	2019	2020	2021	Grand Total
Constrained sPHENIX Labor							
Fixed FY16 Direct Labor w/fringe	3,168,383	4,632,666	4,290,642	7,500,873	5,722,778	976,618	26,291,960
Estimated Composite Indirect on Labor@34.2%	1,083,587	1,584,372	1,467,400	2,565,299	1,957,190	334,003	8,991,850
Fixed FY16 Fully Loaded Labor	4,251,970	6,217,038	5,758,042	10,066,172	7,679,968	1,310,621	35,283,810
Escalation @ 3.0%	0	186,511	350,665	933,134	963,836	208,743	2,642,889
Subtotal AY \$	4,251,970	6,403,549	6,108,706	10,999,306	8,643,804	1,519,364	37,926,699
Contingency at 20%	212,598	320,177	1,221,741	2,199,861	1,728,761	303,873	5,987,012
Budgeted Labor	4,464,568	6,723,726	7,330,448	13,199,167	10,372,565	1,823,237	43,913,711
Adjusted sPHENIX M&S	\$166,000	\$461,000	\$15,077,964	\$5,063,500	\$49,000	\$17,000	\$20,834,464
Estimated Composite Indirect	26,678	76,332	1,351,421	474,415	12,152	4,216	1,945,214
Subtotal FY 16 \$	\$192,678	\$537,332	\$16,429,385	\$5,537,915	\$61,152	\$21,216	\$22,779,678
Escalation @ 2% per FY	0	10,747	663,747	338,965	5,041	2,208	1,020,708
Estimate with Escalation	\$192,678	\$548,079	\$17,093,132	\$5,876,880	\$66,193	\$23,424	\$23,800,386
Contingency @ 30%	9,634	27,404	5,127,940	1,763,064	19,858	7,027	6,954,927
Budget Material	\$202,312	\$575,483	\$22,221,072	\$7,639,944	\$86,051	\$30,451	\$30,755,312
Total AY \$ with Contingency Estimate(20%L,30%M)	\$ 4,666,880	\$ 7,299,209	\$ 29,551,519	\$ 20,839,110	\$ 10,458,616	\$ 1,853,688	\$ 74,669,023

Labor in FTEs by BNL Department

WBS Level 2	(Multiple Items)							
Sum of FTE (1760)	Column Labels							
Row Labels	FY 16	FY 17	FY 18	FY 19	FY 20	FY 21	Grand Total	
Physics	15.2	24.3	20.2	36.2	31.2	5.2	132.2	
Administrative	0.3	0.6	0.6	0.6	0.6	0.3	3.0	
Engineering	7.0	11.0	8.3	10.6	6.0	1.4	44.2	
Proj Mgt Sci	1.2	2.3	2.3	2.3	2.3	1.2	11.4	
Technical	6.7	10.4	9.0	22.7	22.4	2.4	73.7	
Magnet Div	1.1	0.3	0.8	0.9	0.2		3.3	
Engineering	0.7	0.3	0.5	0.6	0.0		2.1	
Technical	0.5	0.1	0.3	0.2	0.1		1.2	
F&O		0.0	0.5	3.3	1.3	0.2	5.2	
Purchased Services		0.0	0.5	3.3	1.3	0.2	5.2	
CA-D	2.6	3.0	4.2	5.9	3.6	0.4	19.6	
Engineering	2.4	2.9	3.1	3.5	2.6	0.4	14.9	
Technical	0.2	0.0	1.1	2.4	1.0		4.6	
Grand Total	18.9	27.6	25.7	46.2	36.3	5.8	160.3	

Labor in FY16\$ Direct by Department

Sum of Costs	Column Labels						
Row Labels	FY 16	FY 17	FY 18	FY 19	FY 20	FY 21	Grand Total
CA-D	\$468,464	\$532,444	\$708,683	\$983,856	\$620,536	\$69,348	\$3,383,330
Engineering	\$440,825	\$531,211	\$554,756	\$648,387	\$476,307	\$69,348	\$2,720,834
PROF3 AD	\$1,797	\$59,833	\$70,578		\$1,150	\$359	\$133,718
PROF4 AD	\$439,028	\$471,378	\$484,177	\$648,387	\$475,157	\$68,988	\$2,587,116
Technical	\$27,639	\$1,233	\$153,928	\$335,469	\$144,228		\$662,496
TECH3 AD	\$27,639	\$1,233	\$153,928	\$335,469	\$144,228		\$662,496
F&O		\$7,263	\$98,246	\$649,535	\$257,014	\$33,775	\$1,045,833
Purchased Services		\$7,263	\$98,246	\$649,535	\$257,014	\$33,775	\$1,045,833
CRAFT3		\$7,263	\$98,246	\$649,535	\$257,014	\$33,775	\$1,045,833
Magnet Div	\$186,146	\$58,590	\$133,514	\$146,845	\$24,935		\$550,030
Engineering	\$119,319	\$47,561	\$86,800	\$111,810	\$8,553		\$374,043
PROF3 AM			\$14,374				\$14,374
PROF4 AM	\$119,319	\$47,561	\$72,426	\$111,810	\$8,553		\$359,668
Technical	\$66,826	\$11,030	\$46,714	\$35,035	\$16,382		\$175,987
TECH3 AM	\$66,826	\$11,030	\$46,714	\$35,035	\$16,382		\$175,987
Physics	\$2,513,773	\$4,034,368	\$3,350,198	\$5,720,637	\$4,820,293	\$873,495	\$21,312,766
Administrative	\$33,363	\$65,413	\$65,151	\$65,413	\$65,676	\$33,374	\$328,390
ADMIN1 PO	\$33,363	\$65,413	\$65,151	\$65,413	\$65,676	\$33,374	\$328,390
Engineering	\$1,271,364	\$2,002,653	\$1,513,473	\$1,925,644	\$1,075,252	\$248,009	\$8,036,395
PROF3 PO E	\$45,639	\$89,481	\$89,121	\$89,481	\$64,325		\$378,047
PROF3 PO M	\$13,224	\$57,209	\$14,015	\$11,356	\$54,479		\$150,284
PROF4 PO E	\$174,673	\$280,400	\$198,170	\$223,035	\$31,207	\$21,194	\$928,679
PROF4 PO M	\$1,037,827	\$1,575,563	\$1,212,166	\$1,601,772	\$925,241	\$226,816	\$6,579,385
Proj Mgt Sci	\$246,888	\$484,056	\$482,112	\$484,056	\$486,000	\$248,832	\$2,431,944
SCI3_PO_PM	\$246,888	\$484,056	\$482,112	\$484,056	\$486,000	\$248,832	\$2,431,944
Technical	\$962,158	\$1,482,246	\$1,289,463	\$3,245,524	\$3,193,366	\$343,280	\$10,516,037
TECH3 PO D	\$778,632	\$864,547	\$352,221	\$222,668	\$38,870	\$6,553	\$2,263,490
TECH3 PO E	\$8,629	\$4,542	\$53,850	\$306,298	\$352,622	\$222,538	\$948,480
TECH3 PO M	\$174,897	\$613,157	\$883,392	\$2,716,558	\$2,801,874	\$114,189	\$7,304,067
Grand Total	\$3,168,383	\$4,632,666	\$4,290,642	\$7,500,873	\$5,722,778	\$976,618	\$26,291,958

Estimated Tracker Costs

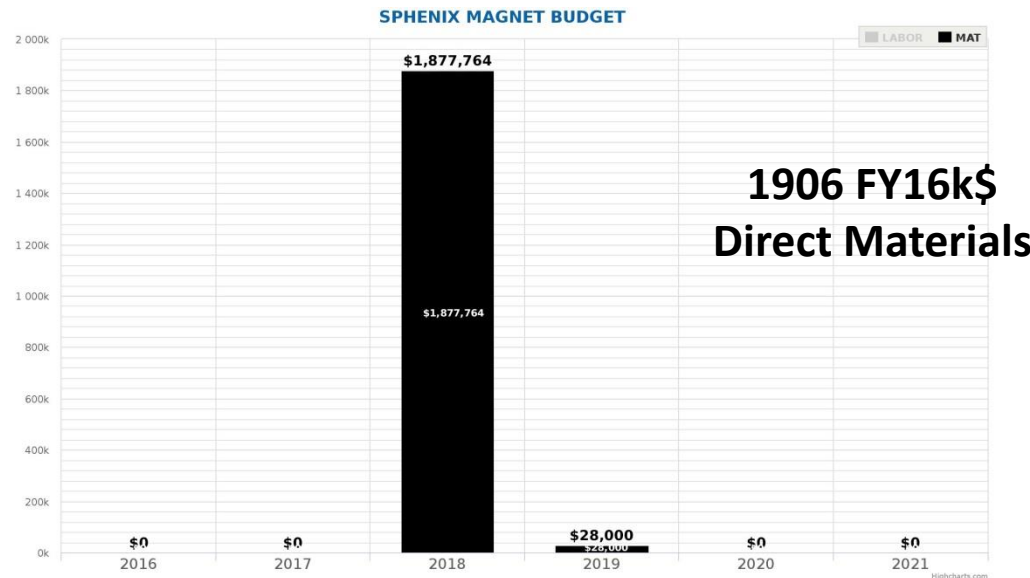
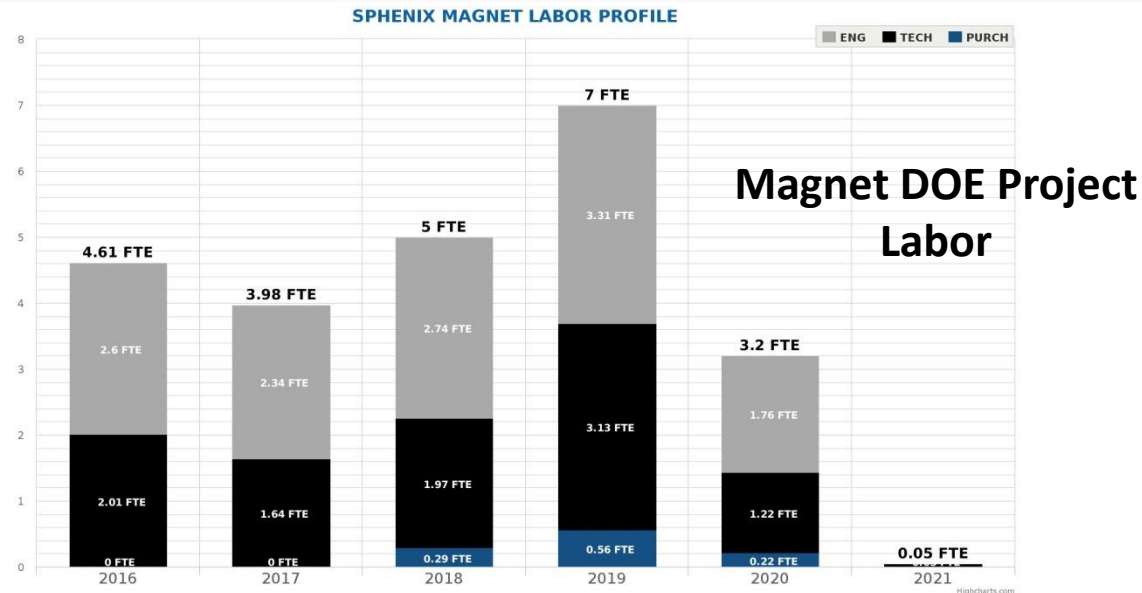
Summary of WBS 1.3 Tracker Fixed FY 16 k\$'s

	WBS	WBS Description	Labor	k\$'s Material	Total
Option 1	1.3	Tracker - Si	2926	4738	7664
Option 2	1.3	Tracker - TPC	1889	2172	4061

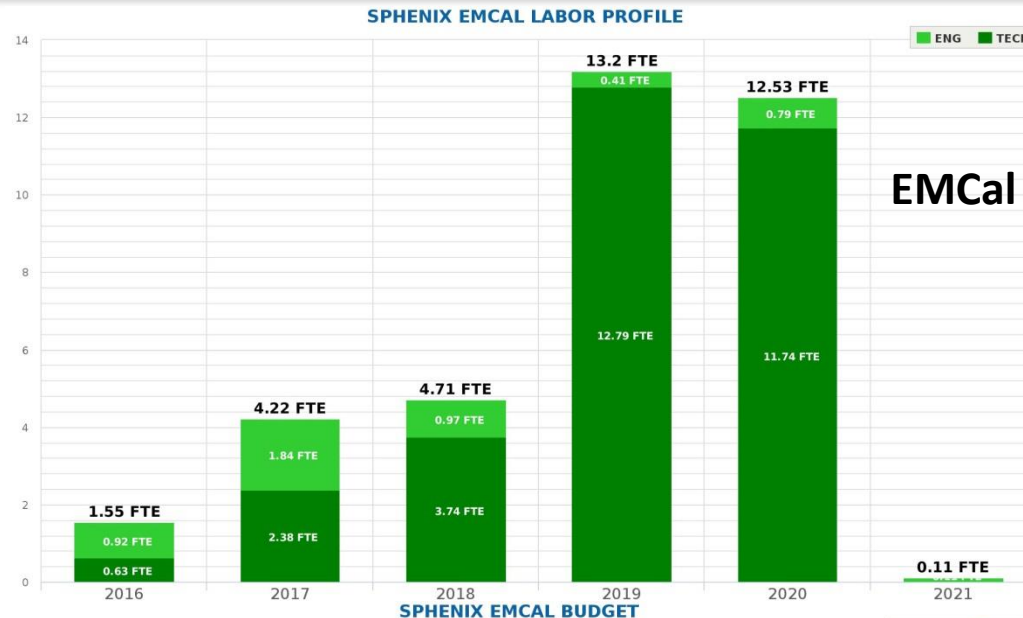
Tracker currently has two different technology options and is not part of the proposed DOE TPC estimate.

Labor - based upon BNL FY 16 published standard labor band rates (salary & fringe) as of September 1, 2015 to allow comparative bench marking.

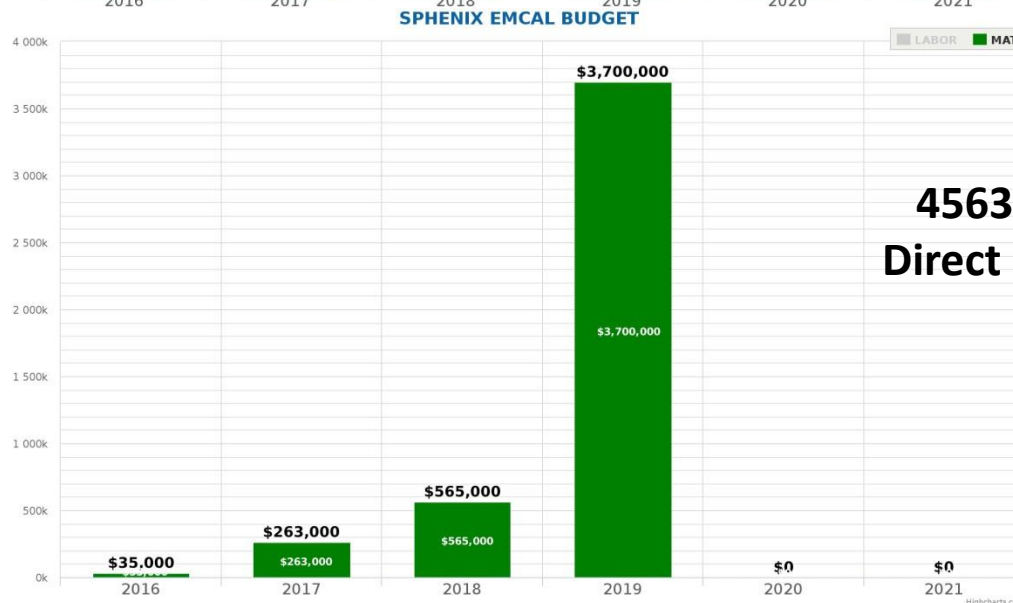
Magnet Direct Materials and Labor FY16\$



EMCal Direct Materials and Labor FY16\$

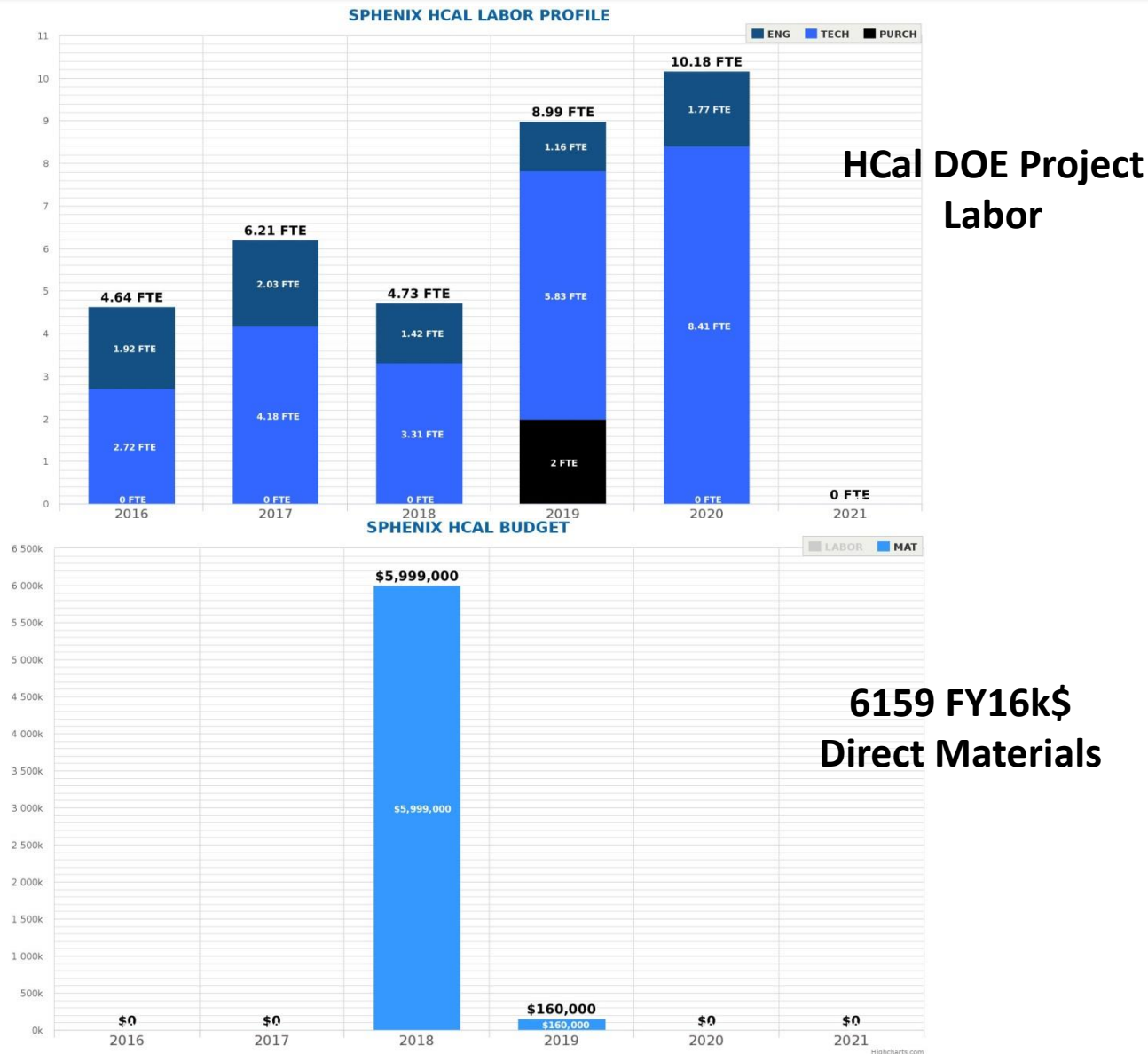


EMCal DOE Project Labor

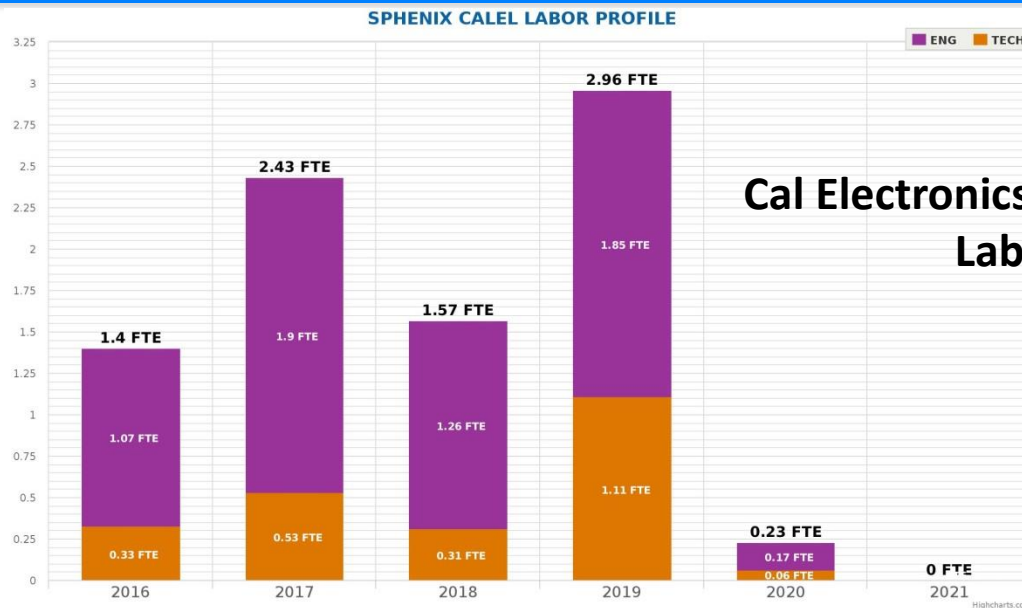


**4563 FY16k\$
Direct Materials**

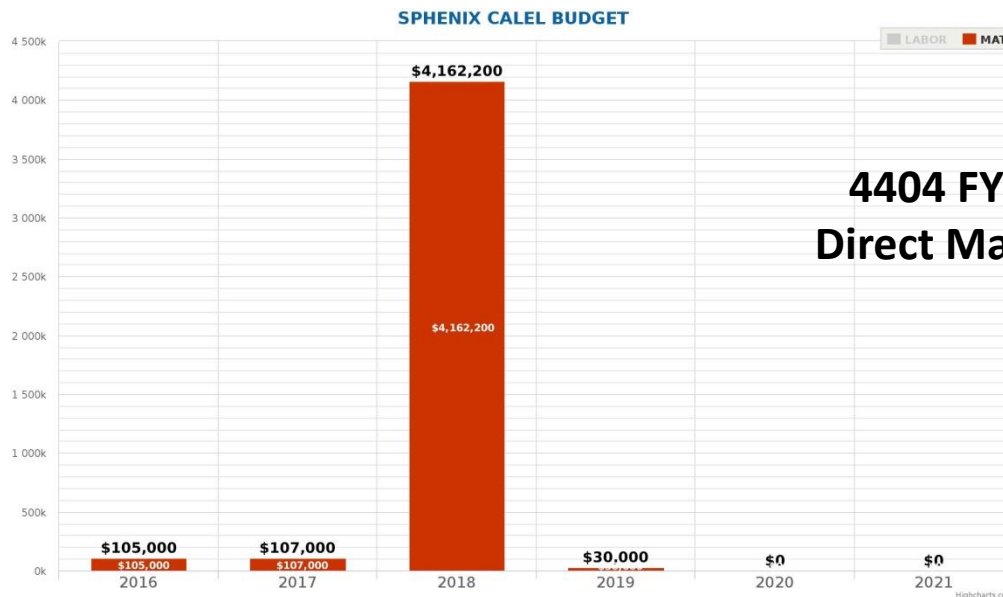
HCal Direct Materials and Labor FY16\$



CalElectronics Direct Materials and Labor FY16\$

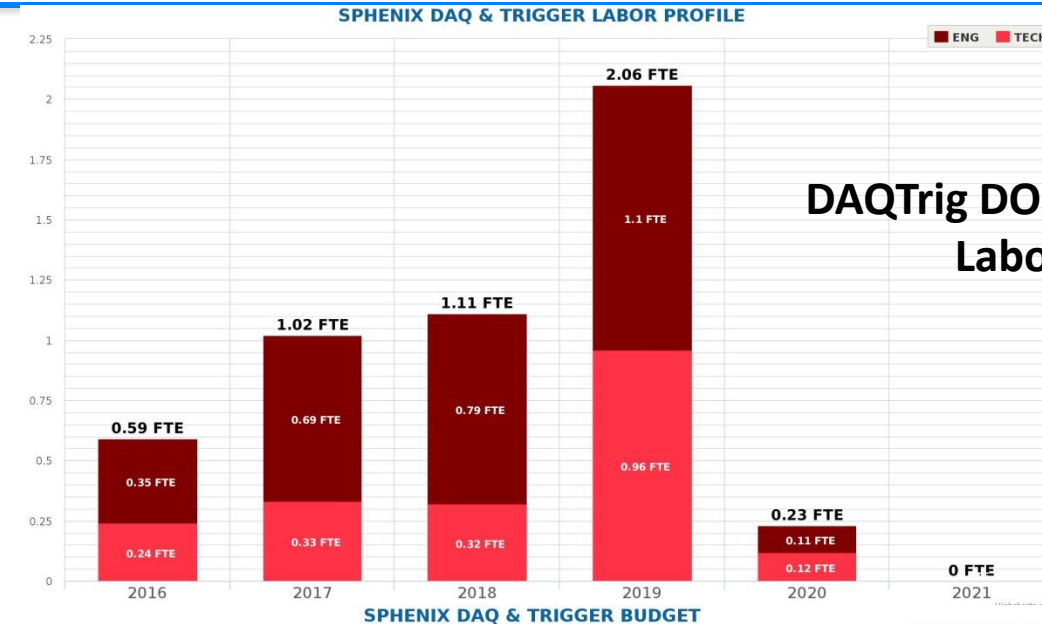


Cal Electronics DOE Project Labor

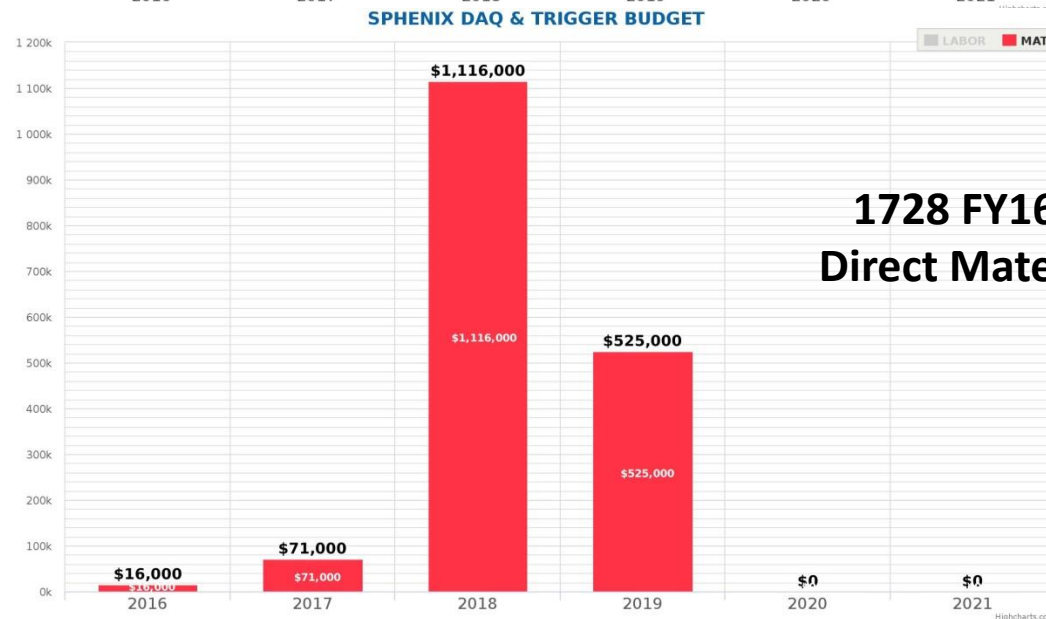


4404 FY16k\$ Direct Materials

DAQTrig Direct Materials and Labor FY16\$

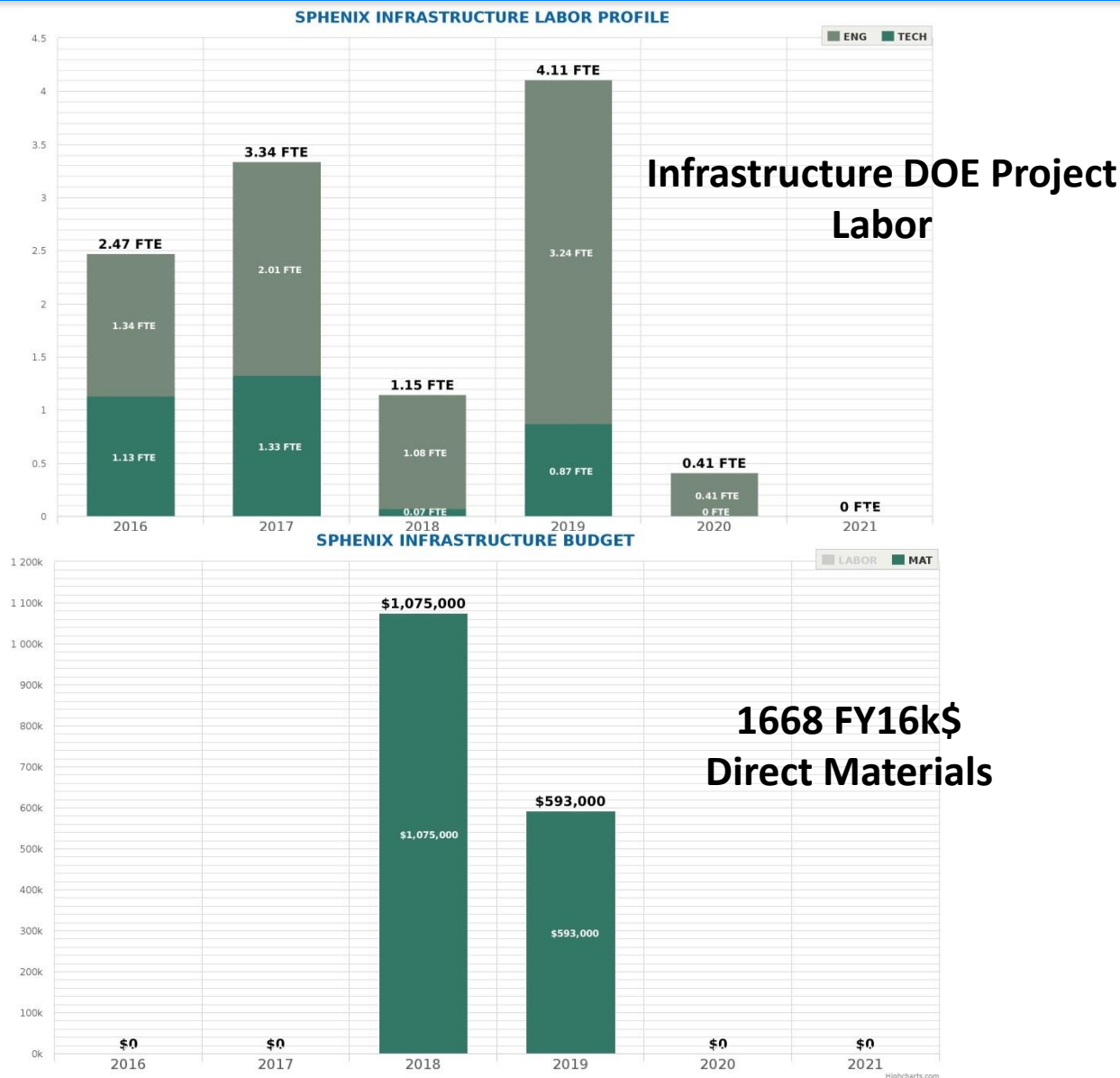


DAQTrig DOE Project Labor

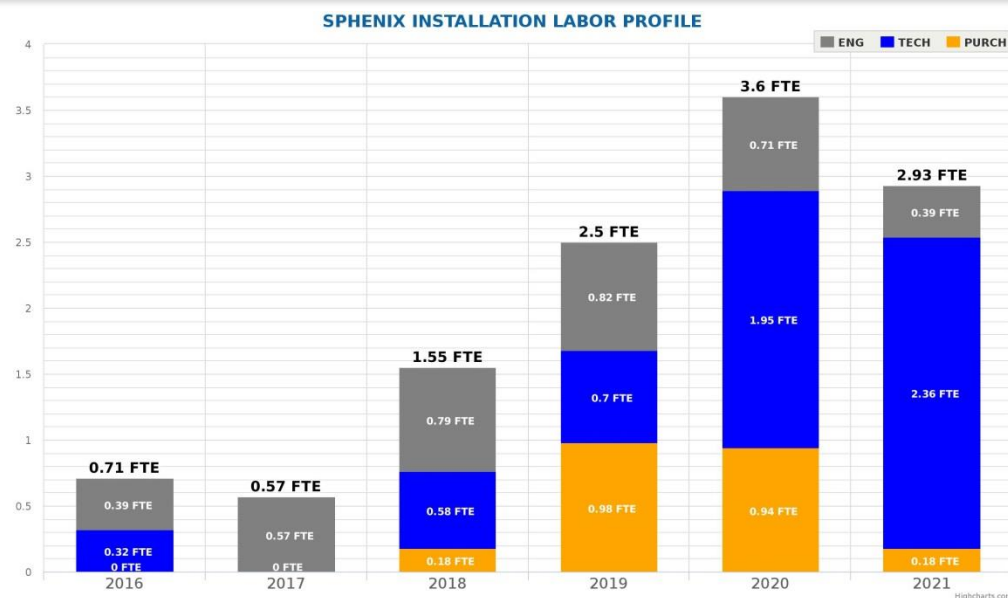


1728 FY16k\$ Direct Materials

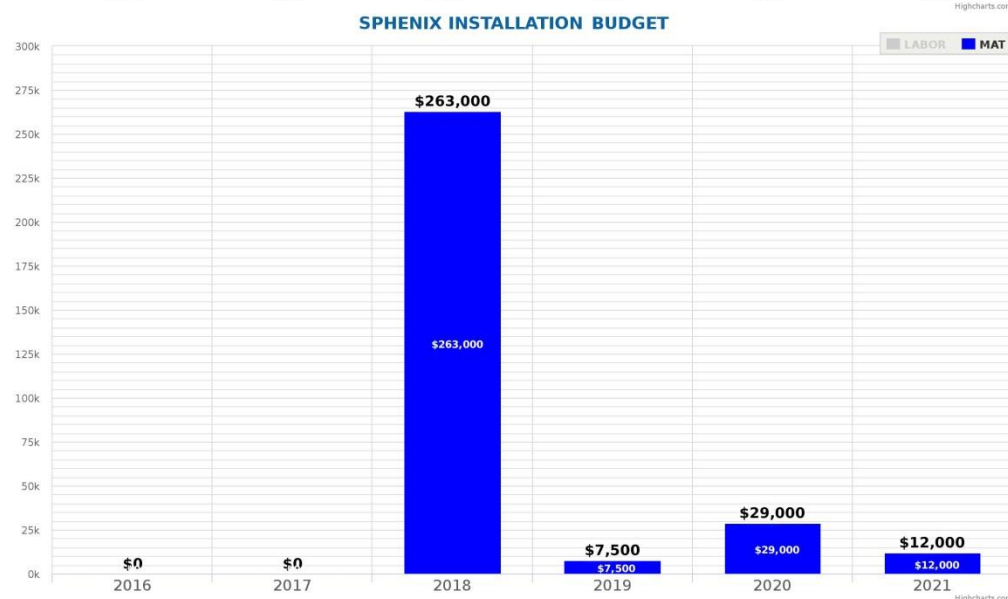
Infrastructure Direct Materials and Labor FY16\$



Installation/Integration Direct Materials and Labor FY16\$PHENIX

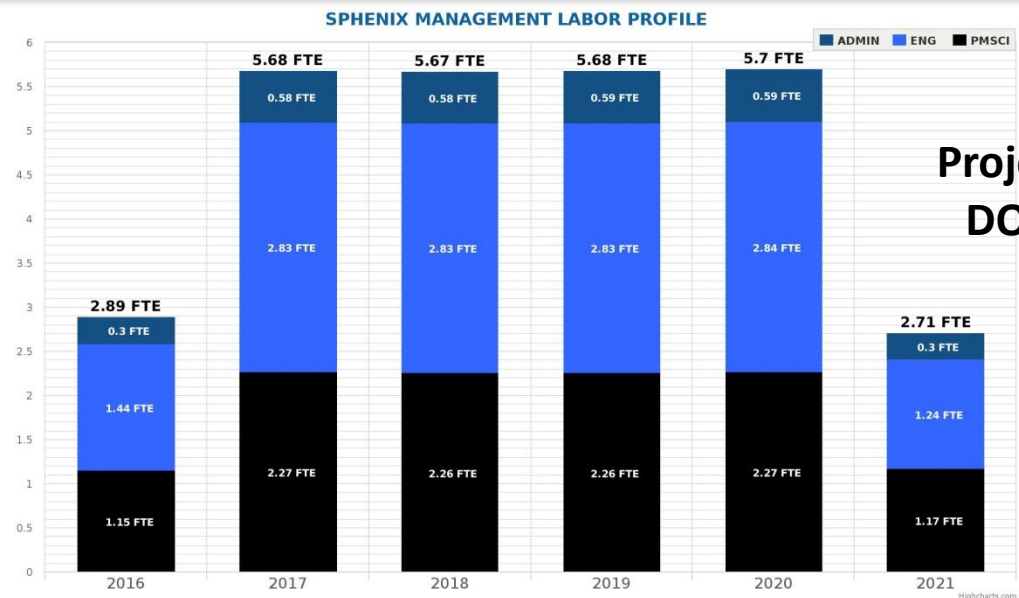


**Installation/Integration
DOE Project Labor**

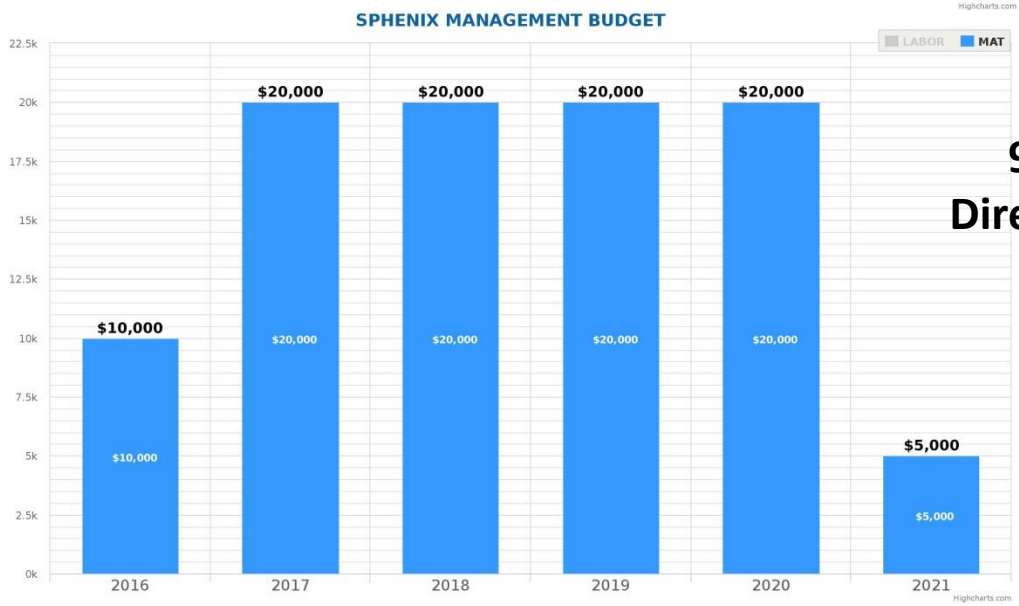


**312 FY16k\$
Direct Materials**

Project Management Direct Materials and Labor FY16\$



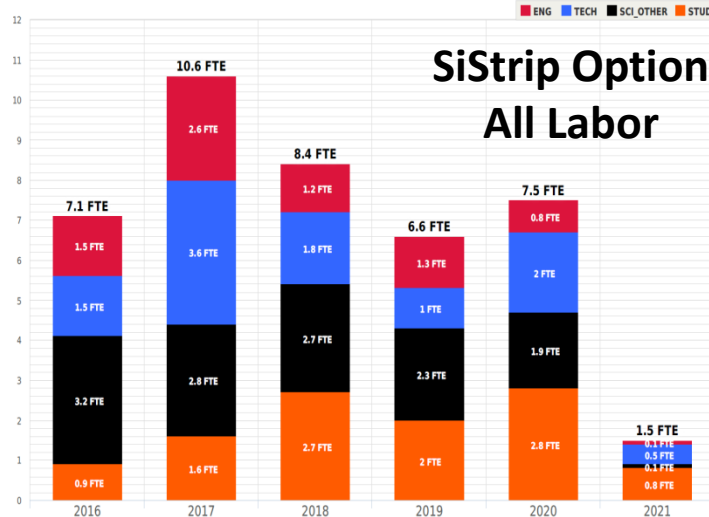
**Project Management
DOE Project Labor**



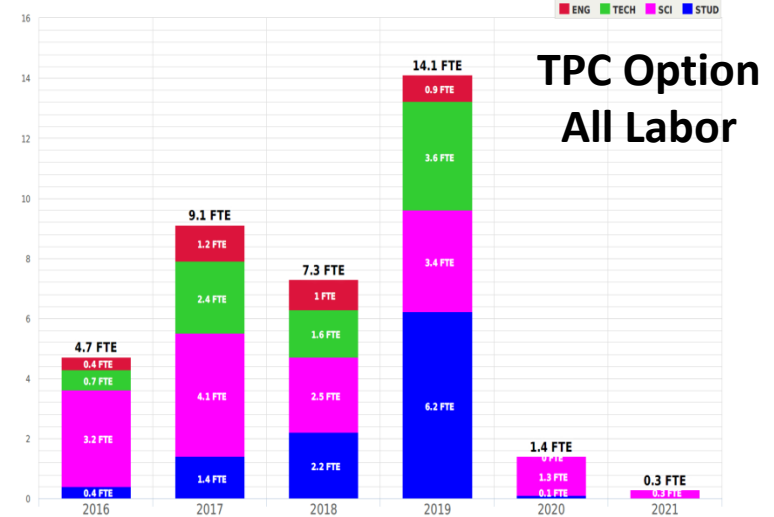
**95 FY16k\$
Direct Materials**

Tracker Direct Materials and Labor FY16\$

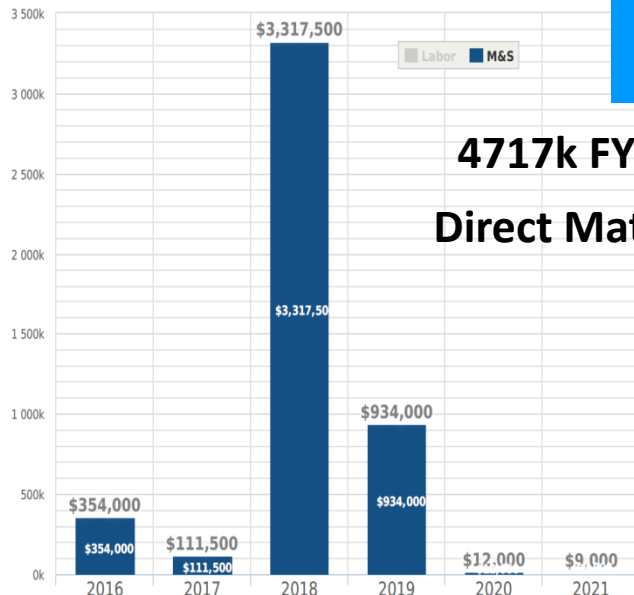
SPHENIX SISTRIIP LABOR



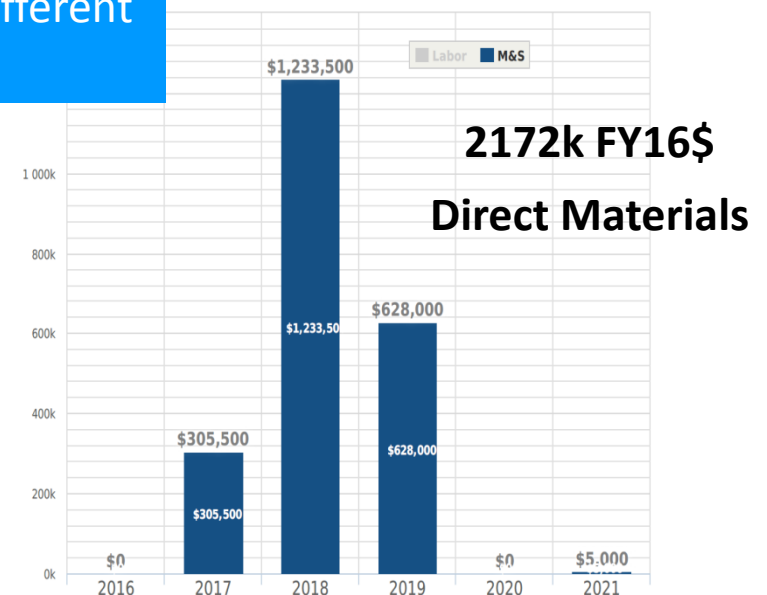
SPHENIX TPC LABOR PROFILE



SPHENIX SISTRIIP BUDGET PROFILE



SPHENIX TPC BUDGET PROFILE



Figures have different scales

Summary

- A Resource-loaded Project Plan has been created for the sPHENIX Project
 - It has been used to analyze resource needs and schedules
 - Material costs have been added to the project plan
 - It is now possible to run project scenarios that would vary CD-X approval dates, resource availability and RHIC schedule
- The Project team has been established and a large team of people are contributing to the planning.
- sPHENIX can be completed for a Jan 2021 beam start but would require a CD-3a in early FY18 that approved long lead time purchases (HCal steel) and an early production start to the SiTracker. The critical path has very little float in this scenario.
- A one year stretch schedule can add significant float to the project, up to 7 months, and help relieve a bump in labor requirements in FY19-20.
- There are a number of places where we believe we can scrub the labor and material costs, and take into account non-DOE funding possibilities. Considerable cost reductions seem possible. This needs to start soon.

Back Up

Reduced Budget Calculation in Detail

All BNL Labor - Different Contingency Approach- Material and Labor Savings

Summary Estimate

	2016	2017	2018	2019	2020	2021	Grand Total
Constrained sPHENIX Labor							
Fixed FY16 Direct Labor w/fringe	3,168,383	4,632,666	4,290,642	6,423,753	4,645,658	976,618	24,137,720
Estimated Composite Indirect on Lab	1,083,587	1,584,372	1,467,400	2,196,924	1,588,815	334,003	8,255,100
Fixed FY16 Fully Loaded Labor	4,251,970	6,217,038	5,758,042	8,620,677	6,234,473	1,310,621	32,392,820
Escalation @ 3.0%	0	186,511	350,665	799,137	782,426	208,743	2,327,482
Subtotal AY \$	4,251,970	6,403,549	6,108,706	9,419,813	7,016,899	1,519,364	34,720,302
Contingency at 20%	212,598	320,177	1,527,177	2,354,953	1,754,225	379,841	6,548,972
Budgeted Labor	4,464,568	6,723,726	7,635,883	11,774,767	8,771,124	1,899,205	41,269,274
Adjusted sPHENIX M&S	\$166,000	\$461,000	\$11,077,964	\$5,063,500	\$49,000	\$17,000	\$16,834,464
Estimated Composite Indirect	26,678	76,332	1,351,421	474,415	12,152	4,216	1,945,214
Subtotal FY 16 \$	\$192,678	\$537,332	\$12,429,385	\$5,537,915	\$61,152	\$21,216	\$18,779,678
Escalation @ 2% per FY	0	10,747	502,147	338,965	5,041	2,208	859,108
Estimate with Escalation	\$192,678	\$548,079	\$12,931,532	\$5,876,880	\$66,193	\$23,424	\$19,638,786
Contingency @ 35%	9,634	27,404	4,526,036	2,056,908	23,168	8,198	6,651,348
Budget Material	\$202,312	\$575,483	\$17,457,569	\$7,933,788	\$89,360	\$31,623	\$26,290,134
Total AY \$ with Contingency Estimate	\$ 4,666,880	\$ 7,299,209	\$25,093,451	\$ 19,708,554	\$ 8,860,485	\$1,930,828	\$ 67,559,407

Labor Table in FTE by FY for DOE Project

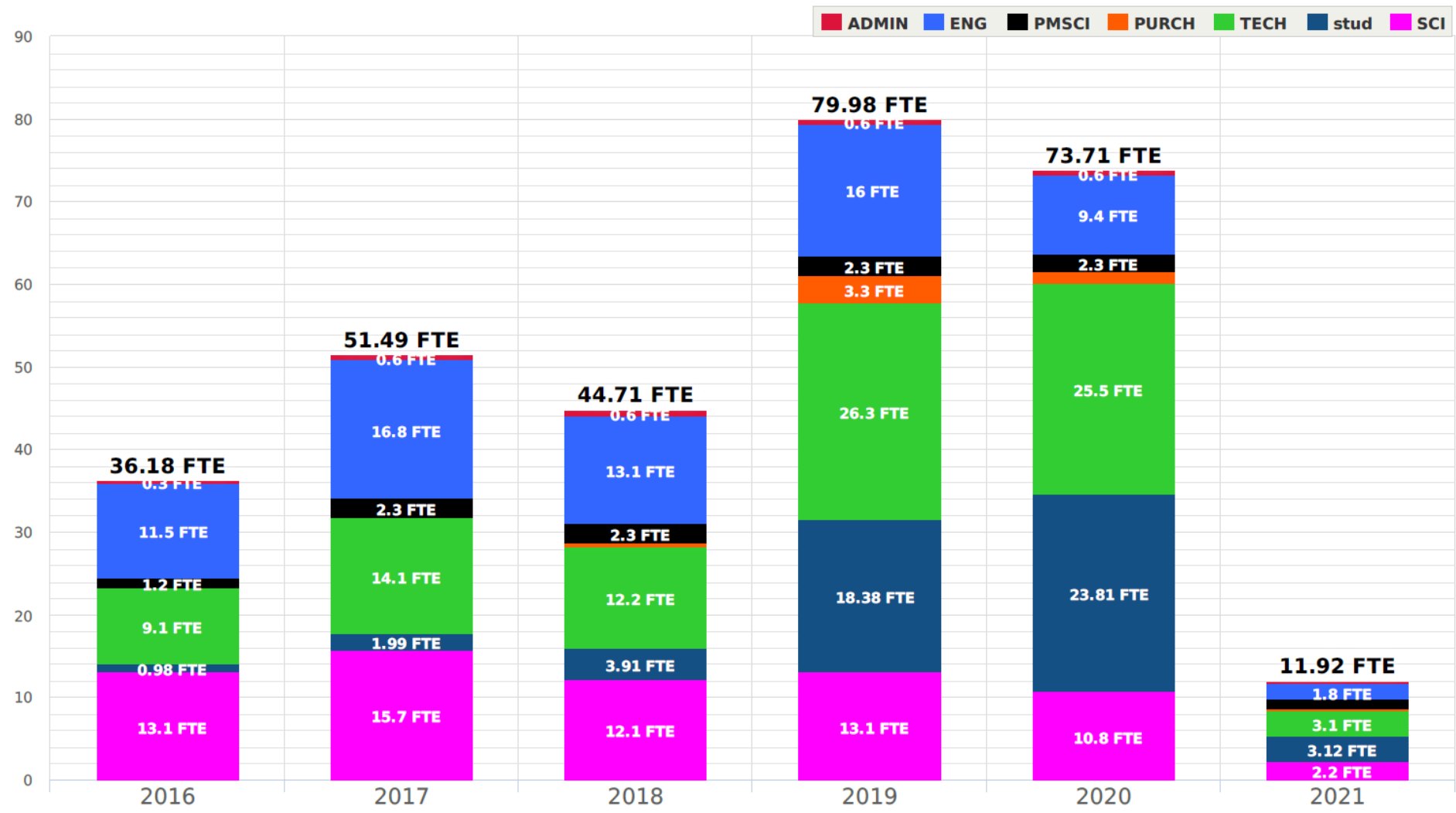
Sum of FTE (1760)		Column Labels						
Row Labels	WBS Description	FY 16	FY 17	FY 18	FY 19	FY 20	FY 21	Grand Total
1.1	Project Management	2.9	5.7	5.7	5.7	5.7	2.7	28.3
	Administrative	0.3	0.6	0.6	0.6	0.6	0.3	3.0
	Engineering	1.4	2.8	2.8	2.8	2.8	1.3	14.0
	Proj Mgt Sci	1.2	2.3	2.3	2.3	2.3	1.2	11.4
1.2	Magnet	4.6	4.0	5.0	6.9	3.2	0.0	23.8
	Engineering	2.6	2.3	2.7	3.3	1.8	0.0	12.7
	Purchased Services			0.3	0.6	0.2		1.1
	Technical	2.0	1.6	2.0	3.1	1.2	0.0	10.0
1.4	EMCaL	1.5	4.2	4.7	13.2	12.5	0.1	36.3
	Engineering	0.9	1.8	1.0	0.4	0.8	0.1	5.0
	Technical	0.6	2.4	3.7	12.8	11.7		31.3
1.5	HCAL	4.6	6.2	4.8	8.7	10.3		34.7
	Engineering	1.9	2.0	1.4	1.2	1.8		8.3
	Purchased Services		0.0	0.0	1.7	0.1		1.9
	Technical	2.7	4.2	3.3	5.9	8.4		24.5
1.6	Cal Elec	1.4	2.5	1.6	2.9	0.2		8.7
	Engineering	1.1	1.9	1.3	1.8	0.2		6.3
	Technical	0.3	0.6	0.3	1.1	0.1		2.4
1.7	DAQ & Trigger	0.6	1.0	1.2	2.1	0.2		5.1
	Engineering	0.4	0.7	0.8	1.1	0.1		3.1
	Purchased Services				0.0			0.0
	Technical	0.3	0.3	0.3	1.0	0.1		2.0
1.8	Infrastructure	2.5	3.4	1.2	4.2	0.4		11.6
	Engineering	1.3	2.0	1.1	3.3	0.4		8.1
	Purchased Services			0.0	0.0			0.0
	Technical	1.1	1.3	0.1	0.9			3.4
1.9	Installation	0.7	0.6	1.5	2.5	3.6	2.9	11.9
	Engineering	0.4	0.6	0.8	0.8	0.7	0.4	3.7
	Purchased Services			0.2	1.0	0.9	0.2	2.3
	Technical	0.3		0.6	0.7	1.9	2.4	5.9
Grand Total		18.9	27.6	25.7	46.2	36.3	5.8	160.4

Sum of FTE (2059)		Column Labels						
Row Labels	WBS Description	Group	FY 16	FY 17	FY 18	FY 19	FY 20	FY 21
1.4	EMCaL	Student	0.00	0.05	0.42	8.07	13.31	0.00
1.5	HCAL	Student	0.00	0.00	0.27	4.16	6.92	0.00
1.6	Cal Elec	Student	0.00	0.00	0.00	2.22	0.38	0.00
1.7	DAQ & Trigger	Student	0.13	0.28	0.51	1.88	0.42	0.00
1.9	Installation	Student	0.00	0.00	0.00	0.00	0.00	2.49
Grand Total			0.13	0.33	1.19	16.34	21.03	2.49

Sum of FTE (1760)		Column Labels						
Row Labels	WBS Description	FY 16	FY 17	FY 18	FY 19	FY 20	FY 21	Grand Total
1.2	Magnet	0.7	0.6	0.6	0.6	0.5	0.1	3.1
	Scientific	0.7	0.6	0.6	0.6	0.5	0.1	3.1
1.4	EMCaL	2.3	2.6	1.5	2.3	3.7	0.1	12.4
	Scientific	2.3	2.6	1.5	2.3	3.7	0.1	12.4
1.5	HCAL	2.2	3.1	2.5	2.2	2.6		12.5
	Scientific	2.2	3.1	2.5	2.2	2.6		12.5
1.6	Cal Elec	0.3	0.5	0.3	0.1			1.2
	Scientific	0.3	0.5	0.3	0.1			1.2
1.7	DAQ & Trigger	0.9	1.6	1.7	2.4	0.4		6.9
	Scientific	0.9	1.6	1.7	2.4	0.4		6.9
1.8	Infrastructure	0.1	0.2	0.1	0.2	0.1		0.7
	Scientific	0.1	0.2	0.1	0.2	0.1		0.7
1.9	Installation	0.1	0.2	0.2	0.2	0.3	1.4	2.5
	Scientific	0.1	0.2	0.2	0.2	0.3	1.4	2.5
Grand Total		6.6	8.8	6.9	8.0	7.6	1.5	39.3

Labor Profile for All incl Scientist and Students

All labor contributions including Univ scientists and students. Includes SiTracker Option



WBS to L4 with Institutions

2	WBS	Name	Institution
3	1.1	Project Management	BNL
4	1.2	Magnet	BNL
5	1.2.1	Magnet Management and Technical Oversight	BNL
6	1.2.2	Magnet Systems Engineering & Design	BNL
7	1.2.2.1	Magnet Mechanical Coil/Core Modifications Engineering and Design	BNL
8	1.2.2.2	Cryogenics System Engineering & Design	BNL
9	1.2.2.3	Magnet Power Supply and Quench Protection Engineering and Design	BNL
10	1.2.2.4	Magnet Field Measurements Engineering & Design, Field Studies & Stress Analysis	BNL
11	1.2.3	Magnet Systems Fabrication	BNL
12	1.2.3.1	Magnet Mechanical Coil/Core Modifications Fabrication	BNL
13	1.2.3.2	Cryogenics System Fabrication	BNL
14	1.2.3.3	Magnet Power Supply and Quench Protection Fabrication	BNL
15	1.2.3.4	Magnet Field Measurements Equipment Purchase and Fabrication	BNL
16	1.2.3.5	Complete Magnet Parts/Component Fabrication	BNL
17	1.2.4	Magnet Systems Installation/Testing	BNL
18	1.2.4.1	Magnet Mechanical Coil/Core Modifications Installation and Testing	BNL
19	1.2.4.2	Cryogenics System Installation/Testing	BNL
20	1.2.4.3	Magnet Power Supply and Quench Protection Installation and Testing	BNL
21	1.2.4.4	Magnet Field Measurements Installation and Test, Post-Test Field Studies and Stress Analysis,	BNL
22	1.2.4.5	Complete Magnet Installation and Testing	BNL
23	1.3	Tracker	
24	1.3.1	Tracker Management	SBU, RIKEN
25	1.3.2	Pixel Detector	BNL or LANL
26	1.3.2.1	Pixel Design	BNL or LANL
27	1.3.2.2	Pixel Production	BNL or LANL
28	1.3.3	Outer SiStrip Detector	RIKEN
29	1.3.3.1	Outer SiStrip Design (Mech and system)	BNL
30	1.3.3.2	SiStrip Prototyping	RIKEN
31	1.3.3.3	Outer SiStrip Production	RIKEN
32	1.3.3.4	SiStrip Electronics	LANL

WBS to L4 by Institution


33	1.3.4	Time Projection Chamber	
34	1.3.4.1	TPC Design	SBU
35	1.3.4.2	TPC Prototype	SBU, WIS
36	1.3.4.3	TPC Production	SBU
37	1.3.4.4	TPC Electronics	ORNL,BNL
38	1.3.5	Final Tracker Assembly/Testing Integration	BNL
39	1.4	EMCal	
40	1.4.1	EMCal Management	BNL
41	1.4.2	EMCal Design	BNL
42	1.4.3	EMCal Prototype	UCLA, BNL
43	1.4.3.1	EMCal Prototype v2	UCLA, BNL
44	1.4.3.2	EMCal Preproduction Prototype	UCLA, BNL
45	1.4.4	EMCal Production	UIUC
46	1.4.4.1	EMCal Tower/Module Production	UIUC
47	1.4.4.2	EMCal Module/Sector Assembly	UIUC
48	1.4.4.3	EMCal Module Testing/Calibration/Integration	UIUC
49	1.5	HCal	
50	1.5.1	HCal management	ISU
51	1.5.2	Inner HCal	WSU, ISU
52	1.5.2.1	Inner HCal design	BNL
53	1.5.2.2	Inner HCal prototype	WSU, ISU
54	1.5.2.3	Inner HCal production	WSU, ISU
55	1.5.3	Outer HCal	BNL
56	1.5.3.1	Outer HCal design	BNL
57	1.5.3.2	Outer HCal prototype	BNL
58	1.5.3.3	Outer HCal production	BNL
59	1.6	Calorimeter Electronics	BNL
60	1.6.1	CalElectronics Management	BNL
61	1.6.2	Calorimeter Optical sensors	BNL
62	1.6.2.1	EMCal Sensor Specification	BNL
63	1.6.2.2	EMCal Sensor Procurement	BNL
64	1.6.2.3	HCal Sensor Specification	BNL
65	1.6.2.4	HCal Sensor Procurement	BNL

WBS to L4 by Institution

65	1.6.2.4	HCal Sensor Procurement	BNL
66	1.6.3	Calorimeter on detector electronics	BNL
67	1.6.3.1	EMCal On detector electronics design	BNL
68	1.6.3.2	EMCal on detector electronics prototype	BNL
69	1.6.3.3	EMCal on detector electronics production	BNL
70	1.6.3.4	HCal on detector electronics design	BNL
71	1.6.3.5	HCal on detector electronics prototyping	BNL
72	1.6.3.6	HCal on detector electronics production	BNL
73	1.6.4	Calorimeter digitizer system	Columbia U
74	1.6.4.1	Calorimeter digitizer design	Columbia U
75	1.6.4.2	Calorimeter Digitizer prototype	Columbia U
76	1.6.4.3	Calorimeter digitizer production	Columbia U
77	1.7	DAQ&Trigger	Columbia U
78	1.7.1	Project oversight and Management	Columbia U
79	1.7.2	DAQ	BNL
80	1.7.2.1	DAQ Design	BNL
81	1.7.2.2	DAQ Prototype	BNL
82	1.7.2.3	DAQ Production	BNL
83	1.7.3	Trigger	TBD
84	1.7.3.1	Trigger LL1	TBD
85	1.7.3.2	Trigger: MB Detector	TBD
86	1.8	Infrastructure	BNL
87	1.08.01	Project Management and Oversight	BNL
88	1.08.02	Infrastructure Design	BNL
89	1.08.03	Infrastructure System Production	BNL
90	1.9	Install & Integration	BNL
91	1.09.01	Integration Supervision	BNL
92	1.09.02	Integration Management and Technical Coordination	BNL
93	1.09.03	Integration/Installation Tooling/Fixture/Procedures Design & Production	BNL
94	1.09.04	sPHENIX Installation	BNL
95	1.09.04.01	Infrastructure Installation	BNL
96	1.09.04.02	CP Carriage Assembly	BNL
97	1.09.04.03	sPHENIX SC Magnet Installation	BNL
98	1.09.04.04	Outer HCal Installation	BNL
99	1.09.04.05	Inner HCal Installation	BNL
100	1.09.04.06	EMCal Installation	BNL
101	1.09.04.07	Tracking Installation	BNL

Basis of Estimate Documents

Fab SC-magnet quench protection

	sPHENIX Detector Relativistic Heavy Ion Collider BASIS of ESTIMATE (BoE)		Date of Est: 10/1/2015
			Prepared by: D. Phillips
			DocNo. (refer Rev. Log):
WBS number: 1.2.3.3.1.3		WBS Title: Procure/Fabricate PS-Mag-QD DC Hook-up Parts	
WBS Dictionary Definition: Refer. WBS Dictionary			
Estimate Type (check all that apply): <input type="checkbox"/> Work Complete <input type="checkbox"/> Existing Purchase Order <input type="checkbox"/> Catalog Listing or Industrial Construction Database <input type="checkbox"/> Documented Vendor Quotation based on Drawings/ Sketches/ Specifications <input type="checkbox"/> Budgetary Estimate by Vendor/Fabricator based on Sketches, Drawings, or other Written Correspondence <input checked="" type="checkbox"/> Engineering Estimate based on Similar Items or Procedures <input type="checkbox"/> Engineering Estimate based on Analysis <input type="checkbox"/> Expert Opinion			
Supporting Documents (including but not limited to): 535mcm cable = 12 cables x (50' PS-WCB + 50' WCB-Mag + 50' Mag-DR + 25' DR-WCB + 50' WCB-PS) x \$16'/ft = \$48k Lugs = 10 locations x 12 lugs/location x \$25/lug = \$3k Water Cooled Buss (WCB) Parts = \$3k Cable Tray Parts = \$4k Miscellaneous Parts = \$2k Total = \$60k			

Details of the Base Estimate (explanation of the Work)

This estimate is for materials for hook-up of the DC power from the Power Supply in 1008B to the Magnet in 1008-IR, including the hook-up to the Dump Resistor (which may be located in 1008B or 1008-IR).

Assumptions Used in Developing Estimate:

- Reusing existing PHENIX Magnet Water Cooled Buss (two pairs of WCB in parallel, with minor modifications) as the connection between 1008B and 1008-IR.
- 12 each 535 MCM cables to carry the 4600 A magnet current.

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Cost Summary

	Material [\$]	Designer [d]	Engineer [d]	Tech [d]	Physicist [d]	Student [d]
Subsystem:	60,000	x	x	x	x	x

Contingency

M&S Contingency Rules Applied

- M4
- Engineering Estimate based on Similar Items

Labor Contingency Rules Applied

- L4
- Engineering Estimate based on Similar Items

Comments:

Provide any additional details that may affect scope, effort, materials, estimating technique, sketches, calculations, etc.

Risk Analysis: (To Be Completed by Subsystem Manager)


- Schedule Risk – (see Impact Assessment Matrix and Risk Classification Matrix)
 - Potential problem:
 - Mitigation:
- Cost Risk – (see Impact Assessment Matrix and Risk Classification Matrix)
 - Potential problem:
 - Mitigation:
- Technical/Scope Risk – (see Impact Assessment Matrix and Risk Classification Matrix)
 - Potential problem:
 - Mitigation:

Subsystem Manager: _____ Date: _____

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Basis of Estimate Documents

Procure SiPMs for EMCal

	sPHENIX Detector Relativistic Heavy Ion Collider BASIS of ESTIMATE (BoE)	Date of Est: 26-Oct-2015
		Prepared by: E.J. Mannel
		DocNo. (refer Rev. Log): Rev. 1
WBS number: 1.6.2.2.11		WBS Title: Order production EMCal sensors
WBS Dictionary Definition: Procure optical sensors for EMCal and provide over sight of procurement process		
Estimate Type (check all that apply): <input type="checkbox"/> Work Complete <input type="checkbox"/> Existing Purchase Order <input type="checkbox"/> Catalog Listing or Industrial Construction Database <input type="checkbox"/> Documented Vendor Quotation based on Drawings/ Sketches/ Specifications <input checked="" type="checkbox"/> Budgetary Estimate by Vendor/Fabricator based on Sketches, Drawings, or other Written Correspondence <input type="checkbox"/> Engineering Estimate based on Similar Items or Procedures <input type="checkbox"/> Engineering Estimate based on Analysis <input type="checkbox"/> Expert Opinion		
Supporting Documents (including but not limited to): <i>For example, attach an engineering estimate or budgetary quote, along with supporting sketches or calculations.</i>		

Details of the Base Estimate (explanation of the Work)

This BOE is for the procurement of the 98,304 optical sensors required for the EMCal detector. The optical sensors are standard production items for the vendor of the component specified in the reference design. The optical sensors require a dynamic range of 10^4 , a gain of 10^6 and capable of operating in a 1.5T magnetic field.

Assumptions Used in Developing Estimate:

Component cost estimate is based on the number of devices required for reference design plus 10%, and budgetary estimate from vendor. Labor estimate is based on time estimated to update order specifications and verify delivery of components. It is assumed that the optical sensor for both the EMCal and HCal will be identical.

Cost Summary

	Material [S]	Designer [d]	Engineer [d]	Tech [d]	Physicist [d]	Student [d]
Subsystem:	920,000	x	22	x	x	x

Contingency

M&S Contingency Rules Applied

- M4: 40%
- Pricing based on budgetary quote from vendor. Devices are off the self components.

Labor Contingency Rules Applied

- L2- 10%
- Labor is for producing order specification documents, tracking order and verifying delivery of components

Comments:

Provide any additional details that may affect scope, effort, materials, estimating techniques, sketches, calculations, etc.

Risk Analysis: – (To Be Completed by Subsystem Manager)

- Schedule Risk – (see Impact Assessment Matrix and Risk Classification Matrix)
 - Potential problem:
 - Mitigation:
- Cost Risk – (see Impact Assessment Matrix and Risk Classification Matrix)
 - Potential problem:
 - Mitigation:
- Technical/Scope Risk – (see Impact Assessment Matrix and Risk Classification Matrix)
 - Potential problem:
 - Mitigation: